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ART. I.—*Contributions to Meteorology: being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Ninth paper. With Plates I, II and III.

[Read before the National Academy of Sciences, Washington, April 19, 1878.]

Low barometer at Portland, Oregon.

IN my last paper, page 5, I showed that the great storms of the United States frequently come from British Columbia or its vicinity. In order to extend this part of the investigation I selected from the published volumes of the Signal Service observations (Sept., 1872, to Oct., 1874,) all those cases in which the barometer at Portland, Oregon, fell as low as 29·7 inches. These cases amount to sixty-three, and correspond to eighteen different storms, as is shown in the following table, in which column 1st shows the number of the storm; column 2d shows the date at which the barometer was below 29·7 inches; column 3d shows the height of the barometer at Portland at the date mentioned; column 4th shows the direction of the wind, and column 5th shows its velocity at Portland at the date mentioned; column 6th shows the rain-fall at Portland during the preceding eight hours; column 7th shows the least height of the barometer observed at that hour at any station within the same low area; column 8th shows the name of the station at which the barometer was lowest; column 9th indicates the region where the storm appears to have originated; Br. Co. denotes British Columbia; Can. denotes Canada, northwest;

Barometer below 29·7 inches at Portland, Oregon.

No.	Date.	Barom.	WIND. Direc.	WIND. Vel.	Rain. 8 hours.	Barom. lowest.	Station.	Originated where.	High on East side. Bar.	High on East side. Station.	Reached At Date.	La
	1872.											
1	Nov. 7.3	29·68	S.	12	0·21	29·68	Portland, Or.	Br. Co.	30·18	Breckenridge	Nov. 12	4
2	Dec. 23.3	·57	N.E.	--	2·40	·57	Portland, Or.	Br. Co.	·95	Breckenridge	Dec. 31	4
	24.1	·15	S.E.	--	1·50	·15	Portland, Or.		·85	LaCrosse		
	24.2	·40	S.E.	4	·29	·37	Fort Benton		·64	Davenport		
	24.3	·62	S.E.	9	·05	·58	Virginia City		·64	Kingston		
	25.3	·64	N.E.	4	·32	·64	Portland, Or.		·77	Pembina		
	26.1	·65	E.	4	1·30	·65	Portland, Or.		·92	Breckenridge		
	1873.											
3	Jan. 4.2	·68	W.	3	·01	·68	Portland, Or.	Br. Co.	·41	Breckenridge	Jan. 11	48
4	Jan. 30.1	·64	S.E.	4	·23	·54	Virginia City	Br. Co.	·32	Pittsburgh	Feb. 5	45
	30.2	·55	S.	3	·06	·55	Portland, Or.		·23	Philadelphia		
	30.3	·55	S.	4	·10	·55	Portland, Or.		·33	Fort Benton		
5	Mar. 30.1	·70	S.E.	20	·40	·70	Portland, Or.	Br. Co.	·20	San Francisco	Apr. 3	48
	30.2	·69	S.W.	8	·23	·56	Fort Benton		·23	San Francisco		
6	April 2.1	·68	S.E.	3	·09	·33	Alpena	Br. Co.	·18	Eastport	Apr. 10	42
	2.2	·49	S.E.	21	·24	·33	Fort Garry		·05	Punta Rassa		
	2.3	·67	S.	12	·21	·40	Virginia City		·08	Punta Rassa		
7	Ap. 20.3	·66	S.E.	2	0	·66	Portland, Or.	Br. Co.	·16	Galveston	Apr. 23	35
8	Dec. 5.2	·69	E.	10	0	·69	Portland, Or.	Pac. O.	·64	LaCrosse	Dec. 9	48
9	Dec. 15.1	·62	S.	4	·02	·62	Portland, Or.	Br. Co.	·47	**Vicksburg**	**Dec. 20**	**45**
	15.2	·67	S.	24	·02	·67	Portland, Or.		·39	**Charleston**		
	1874.											
10	Jan. 1.3	·70	S.	8	·29	·45	Fort Benton	Can.	·64	**Sydney**	**Jan. 5**	**48**
	2.1	·61	S.	16	·03	·26	Fort Garry		·56	**Sydney**		
	2.2	·63	S.E.	8	·03	·09	Fort Sully		·44	**Sydney**		
	2.3	·70	S.	8	·29	·16	Fort Sully		·36	**New London**		
11	Jan. 14.2	·67	Calm	0	0	·67	Portland, Or.	Br. Co.	·89	**Breckenridge**	**Jan. 19**	**45**
	14.3	·59	S.	2	0	·59	Portland, Or.		·87	**Yankton**		
	15.1	·50	S.W.	2	·24	·50	Portland, Or.		·70	**Yankton**		
	15.2	·37	Calm	0	·11	·37	Portland, Or.		·57	LaCrosse		
	15.3	·23	Calm	0	·12	·23	Portland, Or.		·58	Davenport		
	16.1	·11	S.	6	·56	·11	Portland, Or.		·49	Louisville		
	16.2	·06	S.	30	·24	·06	Portland, Or.		·44	Cincinnati		
	16.3	·52	S.	7	·06	·14	Fort Benton		·47	Pittsburgh		
	17.1	·53	S.	2	·01	·00	Fort Garry		·56	Washington		
	17.2	·51	S.	2	0	·25	Fort Garry		·56	Philadelphia		
	17.3	·58	S.	4	0	·33	Fort Sully		·60	Philadelphia		
	18.1	·47	S.	28	0	·42	Virginia City		·62	Philadelphia	**Jan. 23**	**46**
	18.2	·60	S.W.	8	1·09	·45	Virginia City		·55	New London		
	18.3	·67	S.E.	4	·28	·67	Portland, Or.		·47	Boston		
	19.1	·56	S.	12	·22	·56	Portland, Or.		·49	Pembina		
	19.2	·65	S.W.	8	0	·63	Virginia City		·40	Marquette		
12	Feb. 10.3	·67	S.	8	0	·63	Virginia City	Br. Co.	·27	**Mobile**	**Feb. 14**	**50**
	11.3	·63	Calm	0	·10	·17	Fort Garry		·15	**Punta Rassa**		
	12.1	·60	Calm	0	0	·15	Leavenworth		·24	**Brockville**		
	12.2	·57	S.E.	12	·51	·08	Dubuque		·24	**New London**		
	12.3	·44	S.E.	5	·16	·35	Virginia City			**?**	**Feb. 16**	**47**
	13.1	·42	S.	13	·42	·39	Virginia City			**?**		
	13.2	·49	S.	10	·06	·41	Virginia City			**?**		
	13.3	·67	N.W.	8	·31	·47	Virginia City		·18	**Cairo**		
13	Feb. 28.2	·67	S.	16	0	·67	Portland, Or.	Br. Co.	·28	**Norfolk**	**Mar. 4**	**46**
14	Mar. 2.3	·47	S.W.	20	1·15	·47	Portland, Or.	Br. Co.	·36	**Sydney**	**Mar. 8**	**47**
	3.1	·61	S.	16	0	·29	Leavenworth		·34	**Sydney**		
15	Mar. 7.1	·55	S.	12	·56	·55	Portland, Or.	Br. Co.	·23	**Fort Sully**	**Mar. 11**	**30**
	7.2	·60	S.	10	·06	·60	Portland, Or.		·28	**Yankton**		
	7.3	·67	S.	12	·06	·67	Portland, Or.		·45	**Yankton**		
16	Mar. 12.2	·64	S.	13	0	·64	Portland, Or.	Br. Co.	·44	**Breckenridge**	**Mar. 20**	**48**
	12.3	·70	S.W.	8	·07	·61	Virginia City		·45	**Breckenridge**		
	14.1	·66	S.	8	·15	·66	Portland, Or.		·45	**Escanaba**		
	15.2	·50	S.	8	·14	·40	Fort Sully		·42	**Kingston**		
	15.3	·58	S.	2	·03	·40	Virginia City		·43	**Burlington**		
	16.1	·69	Calm	0	0	·26	Fort Sully		·51	**New London**		
17	Ap. 12.1	·64	S.	3	·08	·49	Fort Sully	Pac. O.	·66	**Alpona**	**Apr. 16**	**4**
18	Ap. 30.1	·63	S.	4	·25	·52	Fort Sully	Br. Co.	·37	**Montgomery**	**May 4**	**3**
	30.2	·66	S.	9	·33	·13	Fort Sully		·22	**Mobile**		

and Pac. O. denotes Pacific Ocean; column 10th shows the highest pressure observed at any station at the date mentioned in column 2d; and column 11th indicates the station at which this pressure was observed. Each of these areas of low pressure appears to have moved eastward, and can be traced to the Atlantic coast. Column 12th shows the date at which the center of low pressure reached the Atlantic coast, and column 13th shows the latitude of the low center at that time.

A comparison of these cases shows that they all occurred during the six colder months of the year, and they were most numerous in January. In a majority of the cases the wind blew from the south, and in only three cases did the wind blow from any northern quarter. The greatest force of the wind in any case was thirty miles per hour; in six cases it rose as high as twenty miles per hour, and the average velocity was 8·2 miles per hour.

In forty-six per cent of the cases, the pressure at Portland was lower than at any other station at the same hour; in twenty-seven per cent of the cases, the lowest pressure was at Virginia City or Fort Benton; in thirteen per cent of the cases, the lowest pressure was at Fort Sully; and in the remaining cases the lowest pressure was at some station still further east. A comparison of the observations at Virginia City with those at neighboring stations indicates that the readings of the barometer at Virginia City are too low, and accordingly they have all been increased by 0·26 inch.

With but two exceptions, all of these cases of low pressure appear to have originated north of Portland, and generally west of that station. In the table, this region is designated by the term British Columbia. It is probable that in some of these cases, and perhaps in all of them, the area of low pressure was first formed over the Pacific Ocean. No. 10 was apparently formed on the east side of the Rocky Mountains, but north of the United States, a region designated as Canada N. W. Nos. 8 and 17 were apparently formed over the Pacific Ocean, near the latitude of San Francisco.

In a majority of these cases there was an area of high barometer on the east side of Portland, at an average distance of about 1500 miles. In one case the barometer rose to 30·95 inches; in six cases the barometer rose as high as 30·75 inches; in one-third of the cases the pressure rose to 30·5 inches; and in more than two-thirds of the cases the pressure rose to 30·25 inches. In five cases (out of sixty-three) there was no station within the limits of the United States where the pressure rose as high as 30·15 inches at the dates mentioned. No. 17 is represented on Plate III accompanying the present paper, and No. 2 is represented on Plate I accompanying my fifth paper.

In each case the center of low pressure traveled eastward, and can be traced to the Atlantic coast. No. 11, being a depressed period of five days' continuance, should probably be regarded as consisting of two depressed areas, the second of which immediately succeeded the first, so that the two were united in Oregon, but traveled across the continent independently, one of them reaching the Atlantic four days later than the other. So also No. 12 apparently consisted of two depressed areas which were united in Oregon, but traveled across the continent independently, one of them two days later than the other. The average time of crossing the continent was five days, and the average latitude where the low center met the Atlantic was 45°.

The paths by which these areas of low pressure crossed the continent differed considerably from arcs of great circles. Starting from the Pacific Ocean, generally as far north as latitude 50°, the course was toward the southeast, until near the middle of the continent, and on the meridian of 100° from Greenwich the average latitude of the paths was 40°. Thence the course gradually veered northward, and upon reaching the Atlantic the average latitude of the paths was 45°.

Low barometer at San Francisco, California.

The observations made at San Francisco have been discussed in the same manner as those at Portland. The following table shows all the cases in which (during a period of twenty-six months) the barometer fell as low as 29·7 inches. The table is constructed in the same manner as that for Portland.

The number of these cases is twenty-nine, corresponding to nine different storms, and most of them occurred during the winter months. A single case is reported for the summer months, which apparently resulted from causes operating over the central portion of the North American continent. In three-fourths of the cases the wind blew from some southern quarter, and in only three cases did it blow from a northern quarter. The average velocity of the wind was fifty per cent greater than at Portland, a result which may be ascribed to greater proximity to the ocean.

In more than one-third of the cases the pressure at San Francisco was the lowest reported at any station at the same hour. In eleven of the cases the greatest depression was on the east side of the Rocky Mountains, and in eight cases the point of greatest depression was situated about 1400 miles eastward. Five of these depressions appear to have originated over the Pacific Ocean; the remaining four appear to have originated north of the United States, two of them on the west side of the Rocky Mountains and two on the east side.

Barometer below 29·7 inches at San Francisco.

Date.	Barom.	WIND.		Rain, 8 hours.	Barom. lowest.	Station.	Originated where.	High on East side.		Reached At'ic.	
		Direc.	Vel.					Bar.	Station.	Date.	Lat.
1872.											
Dec. 28.2	29·68	S.E.	14	0·11	29·68	San Francisco	Pac. O.	30·47	Nashville	Dec. 31	43°
1873.											
Jan. 31.2	·55	S.E.	20	·04	·55	San Francisco	Pac. O.	·78	Breckenridge	Feb. 5	45
31.3	·60	S.W.	4	·28	·60	San Francisco		·85	Breckenridge		
Feb. 1.1	·65	N.E.	4	0	·65	San Francisco		·95	Fort Sully		
1.2	·64	N.	4	0	·64	San Francisco		·82	Leavenworth		
1.3	·67	S.	8	·02	·67	San Francisco		·74	Davenport		
Feb. 24.1	·61	W.	8	·05	·49	Corinne	Pac. O.	·35	Fort Sully	Feb. 28	43
24.2	·60	W.	16	0	·41	Corinne		·28	Fort Sully		
24.3	·64	W.	12	0	·38	Corinne		·36	Fort Sully		
July 1.3	·70	S.W.	12	0	·59	Fort Garry	Can.	·18	Lake City	July 6	45
Sep. 25.3	·68	S.W.	8	0	·14	Fort Sully	Can.	·13	Halifax	?	50 +
26.1	·66	S.W.	12	0	·25	Breckenridge		·21	Washington		
26.2	·66	S.W.	16	0	·20	Fort Garry		·22	Cape May		
26.3	·68	S.W.	12	0	·53	Fort Garry		·26	Philadelphia		
Dec. 3.3	·67	S.E.	20	·76	·66	Cheyenne	Pac. O.	·28	Charleston	Dec. 9	48
4.1	·63	N.W.	16	·72	·63	San Francisco		·42	St. Louis		
4.2	·57	S.	20	·08	·57	San Francisco		·39	Cairo		
4.3	·55	S.	20	·05	·55	San Francisco		·55	Fort Sully		
5.1	·62	S.	8	·99	·62	San Francisco		·65	Fort Sully		
7.1	·70	S.E.	8	·25	·61	Corinne		·71	Kingston		
7.3	·67	S.E.	4	·07	·66	Cheyenne		·71	Montreal		
8.1	·69	Calm	0	0	·69	San Francisco		·76	Chatham		
1874.											
Jan. 15.3	·55	S.	28	·31	·23	Portland, Or.	Br.Col.	·58	Davenport	Jan. 19	45
16.1	·58	S.W.	24	·22	·11	Portland, Or.		·49	Louisville		
16.3	·67	S.W.	8	0	·14	Fort Benton		·47	Pittsburgh		
17.1	·56	S.	24	·41	·00	Fort Garry		·56	Lynchburg		
17.2	·63	S.W.	16	·35	·25	Fort Garry		·56	Philadelphia		
Feb. 12.1	·70	S.W.	12	·07	·15	Leavenworth	Br.Col.	·24	Brockville	Feb. 14	50
Apr. 11.1	·70	W.	16	0	·62	Salt Lake City	Pac. O.	·45	Pembina	Ap. 16	48

In nearly all of these cases there was an area of high barometer on the east side of San Francisco at an average distance of 1500 miles. In one case the barometer rose to 30·95 inches, and in two-thirds of the cases it was as high as 30·36 inches. In No. 4 a moderate depression of the barometer extended over the entire United States, with the exception of the southeast portion. This low area continued to cover a considerable part of the United States without much change during a period of fifteen days.

In each of these cases (with perhaps a single exception) the center of low pressure traveled eastward across the Rocky Mountains, and can generally be traced entirely across the continent, although in some cases the barometric wave experienced considerable modification in its progress. On account of the uncertainty attending the reduction of the mountain observations to the level of the sea, the progress of the barometric wave is best exhibited by the *changes* of pressure, without regard to

the absolute height of the barometer. Plate I exhibits the oscillations of the barometer for Nos. 2, 3 and 9 at San Francisco and several other stations, extending eastward to the Valley of the Mississippi, and a change of pressure of one-tenth of an inch is represented by one-tenth of an inch in the diagram. Plate II represents three other cases in which the minimum of pressure is pretty sharply defined, and the progress of the barometric wave is very distinctly indicated. These examples show conclusively that barometric waves sometimes travel from the Pacific coast across the Rocky Mountains into the Valley of the Mississippi, with so little change as to leave no doubt of their identity. It will be noticed, however, that the barometric oscillation generally increases quite rapidly as soon as the wave reaches the Mississippi Valley; and in several of the diagrams palpable changes will be perceived in the form of the curves from one station to another. In several of the cases, not here represented, these changes are still more considerable.

The minimum at Salt Lake City usually occurs about sixteen hours later than at San Francisco, and at Cheyenne about one day later than at San Francisco. This indicates a velocity of forty miles per hour, which is greater than the velocity usually found for barometric waves; but it is probable that the motion of the center of low pressure was not parallel to the line joining San Francisco and Cheyenne, so that the velocity of the center of low pressure was less than forty miles per hour. It seems, then, to be clearly established that barometric waves frequently travel from the Pacific coast across the Rocky Mountains and reach the Mississippi Valley with but little modification. The Rocky Mountains form an uninterrupted barrier 6,000 feet in height from British America southward to latitude 32°, and the Sierra Nevadas present a barrier of the same height extending from British America southward to latitude 36°, with but three interruptions amounting in the aggregate to less than one hundred miles. The Rocky Mountains form a barrier of 10,000 feet in height, which extends nearly half the distance from latitude 49° to latitude 32°, and which is continuous for about 350 miles in the neighborhood of Colorado. The Sierra Nevadas also present short ranges of equal altitude, but the longest of them is less than 150 miles.

Thus we see that an unbroken mountain range of 6,000 feet in height cannot stop the progress of atmospheric waves; neither do ranges of more than 10,000 feet in height, broken as in North America, present any insuperable obstacle. A great barometric depression requires either a wind blowing with a hurricane velocity, or else a system of converging winds extending over a vast area. The mountain ranges between the Pacific Ocean and the Mississippi Valley present obstructions to the formation

of a system of winds of very great geographical extent, and this is probably one reason why the barometric fluctuations at the mountain stations are less than they are in the Mississippi Valley. The oscillations of the barometer are generally somewhat greater at Salt Lake City than at San Francisco, and generally they become very much magnified after crossing the Rocky Mountains. The depression of the barometer at the center of a great storm is mainly due to the geographical extent of the system of winds set in motion; and after a storm-center has reached the Mississippi River, there are no mountain barriers to prevent the formation of a system of circulating winds over an area 2,000 miles in diameter.

Areas of high barometer.

Each of the areas of low barometer described in my eighth paper was preceded by an area of high barometer on the east side at an average distance of about 1,000 miles, and was followed by an area of high barometer on the west side at about the same distance.

In order to discover the circumstances under which areas of high barometer originate, and the relations which they bear to areas of low barometer, I selected from the published volumes of the Signal Service observations all those cases in which the barometer at any station rose above 30·65 inches. Sometimes at the same hour the barometer was above 30·65 inches at a considerable number of stations, all included within the same high area. In such cases, only one of the stations was employed, viz., the station at which the barometer was highest. These cases of high barometer are exhibited in the following table, in which column 1st shows the number of the high area; column 2d shows the date at which the barometer was above 30·65 inches; column 3d shows the greatest height of the barometer observed at that hour; column 4th shows the name of the station at which the given height was observed; column 5th shows the temperature at the given station at the given hour; column 6th shows the highest velocity of the wind which preceded each of these areas of high barometer; column 7th indicates the region where this high area appears to have originated; the abbreviations are the same as in the preceding tables, except Ark. which denotes Arkansas; column 9th shows the station where the barometer was lowest on the east side of the high area; column 8th shows the height of the barometer at the given station; column 11th shows the station where the barometer was lowest on the west side of the high area; and column 10th shows the height of the barometer at the given station.

Barometer above 30·65 *inches.*

No.	Date.	Barom.	Station.	Therm.	Wind preceding.	Originated where.	Low on East side. Bar.	Low on East side. Station.	Low on West side. Bar.	Low on West side. Station.
	1872.									
1	Oct. 29.1	30·66	Kingston	33°	33	Can.			29·69	Omaha.
2	Nov 13.3	·79	Fort Benton	13	47	Br.Col.	29·55	St. Paul		
	14.1	·87	do.	11			·63	Marquette		
	14.2	·88	do.	18			·65	Escanaba		
	14.3	·88	do.	0			·51	Montreal		
	15.1	·81	do.	−13			·30	Quebec		
	15.2	·67	do.	14			·59	Quebec		
	16.3	·69	do.	3			·96	Quebec		
	17.1	·75	Nashville	19						
	17.3	·71	Leavenworth	14						
3	Nov 18.2	·67	Portland, Or.	43	32	Br.Col.	·90	Fort Sully		
4	Nov 28.1	·71	Breckenridge	−12	57	Br.Col.	·91	Quebec		
	28.2	·84	do.	− 6			·98	Buffalo		
	28.3	·98	Duluth	0			·78	Rochester	·99	Portland, Or.
	29.1	·93	Breckenridge	−15			·74	Boston	·95	Portland, Or.
	29.2	·71	Memphis	26			·55	Boston	·95	Portland, Or.
5	Dec. 8.2	·70	Breckenridge	− 3	41	Br.Col.	·47	Montreal		
	8.3	·78	do.	−11			·45	Rochester		
	9.1	·82	do.	−14			·42	Montreal		
6	Dec. 21.1	·72	Leavenworth	− 2	38	Br.Col.	·69	Halifax		
	21.2	·71	do.	0			·80	Halifax	·73	Fort Benton.
	21.3	·72	Nashville	10			·88	Oswego	·68	Virginia City.
7	Dec. 23.1	·70	Breckenridge	−33	40	Can.	·71	Alpena	·79	Cheyenne.
	23.2	·88	do.	−24			·74	Montreal	·74	do.
	23.3	·95	do.	−31			·63	Halifax	·57	Portland, Or.
	24.1	·85	LaCrosse	−27			·82	do.	·15	do.
	25.1	·66	Kingston	−21					·68	Cheyenne.
8	Dec. 25.3	·77	Pembina	−24	32	Can.	·72	Wilmington	·64	Portland, Or.
	26.1	·92	Breckenridge	−27			·46	Norfolk	·65	do.
	26.2	·92	do.	−22			·51	New London	·76	do.
	26.3	·84	do.	−27			·31	Halifax	·93	do.
	27.1	·88	do.	−33			·17	do.	·83	Cheyenne.
	1873.									
9	Jan. 12.1	·66	Charleston	36	36	Arkan.			·51	Fort Sully.
10	Jan. 15.1	·81	Portland, Me.	3	40	Can.			·59	Leavenworth.
	15.2	·82	do.	12					·60	Milwaukee.
	15.3	·82	Halifax	10					·67	Alpena.
11	Jan. 16.1	·72	Breckenridge	−26	38	Br.Col.	·59	Louisville		
	16.2	·68	do.	−15			·45	Buffalo		
	16.3	·79	do.	−22			·36	Quebec		
	17.1	·77	do.	−19			·54	Quebec		
	17.3	·66	St. Paul	−15			·80	Wilmington	·95	Fort Benton.
	18.1	·67	LaCrosse	−36			·74	Philadelphia	·90	Fort Benton.
12	Jan. 27.2	·75	Breckenridge	−17	40	Br.Col.	·59	New London	·38	Santa Fe.
	27.3	·92	do.	−29			·17	Halifax	·65	Santa Fe.
	28.1	·85	do.	−35			·37	do.	·82	Santa Fe.
	28.2	·74	Leavenworth	− 3			·76	do.	·78	Santa Fe.
	28.3	·72	do.	−12			·71	do.	·71	Fort Benton.
13	Jan. 31.1	·66	Breckenridge	−17	34	Can.	·82	Quebec	·65	Corinne.
	31.2	·78	do.	−19			·82	Halifax	·55	S. Francisco.
	31.3	·85	do.	−25			·89	Quebec	·48	do.
	Feb. 1.1	·95	Fort Sully	−20			·97	Halifax	·65	S. Francisco.
	1.2	·82	Leavenworth	4			·92	do.	·64	do.
	1.3	·74	Davenport	2			·87	do.	·67	do.

Barometer above 30·65 *inches.*

Date.	Barom.	Station.	Therm.	Wind preceding.	Originated where.	Low on East side. Bar.	Low on East side. Station.	Low on West side. Bar.	Low on West side. Station.
1873.									
Mar. 1.3	30·77	Fort Sully	6°	36	Can.	29·98	Quebec		
2.1	·93	do.	6			·94	do.		
2.2	·84	do.	8			·70	do.		
2.3	·86	Breckenridge	−22			·82	Cape May		
3.1	·88	do.	−31			·58	New London		
3.2	·75	St. Paul	7			·35	Portland, Me.		
3.3	·97	do.	−1			·36	do.	29·97	Portland, Or.
4.1	·91	Omaha	9			·64	do.	·87	do.
4.2	·70	Chicago	20			·88	do.	·76	do.
4.3	·73	do.	11					·75	do.
5.1	·78	Knoxville	11					·70	Fort Benton.
5.2	·69	Port Stanley	20					·55	do.
5.3	·72	Baltimore	23					·52	do.
6.1	·78	Lynchburg	14					·45	do.
6.2	·69	Norfolk	36					·35	Fort Sully.
6.3	·71	Augusta	37					·42	do.
7.1	·67	do.	30					·42	Duluth.
Mar. 24.3	·68	Fort Sully	1	30	Br.Col.	·63	Cairo		
25.1	·76	do.	−5			·64	Nashville	·94	Portland, Or.
Nov 29.1	·66	Pembina	−12	32	Can.	·74	Cape Rosier	·80	Portland, Or.
29.2	·67	do.	−1			·85	do.	·75	do.
29.3	·72	do.	−4			·90	do.	·77	do.
30.1	·70	Kingston	8					·84	do.
30.2	·73	do.	6					·74	Virginia City.
30.3	·77	do.	5					·66	do.
Dec. 1.1	·80	Quebec	−12					·71	Cheyenne.
1.2	·78	Montreal	0					·64	do.
1.3	·77	Father Point	−2					·62	do.
2.1	·84	Chatham	−16					·56	do.
2.2	·79	do.	1					·47	do.
2.3	·71	Halifax	19					·52	Dubuque.
3.1	·67	Sydney	20					·54	Escanaba.
Dec. 5.3	·73	LaCrosse	2	49	Can.			·73	Portland, Or.
6.1	·71	Toledo	23					·76	do.
7.1	·71	Kingston	20					·61	Corinne.
7.3	·71	Montreal	20					·66	Cheyenne.
8.1	·76	Chatham	6					·77	Breckenridge.
Dec. 9.1	·67	Yankton	5	54	Can.	·76	Father Point		
Dec. 19.3	·67	do.	0	31	Br.Col.	·65	Boston		
20.1	·68	do.	−8			·58	Halifax		
Dec. 30.1	·66	Fort Gibson	16	32	Can.	·33	Cape Rosier		
1874.									
Jan. 5.3	·74	Father Point	15	32	Br.Col.			·68	Fort Garry.
6.1	·93	Chatham	6					·85	Fort Garry.
6.2	·79	Cape Rosier	10					·74	Augusta, Ga.
6.3	·67	Chatham	18					·61	do.
Jan. 13.1	·87	Fort Sully	−7	43	Can.			·92	San Diego.
13.2	·81	Breckenridge	−4					·92	do.
13.3	·89	Yankton	−8			·92	Cleveland	·96	do.
14.1	·96	do.	−11			·79	New London	·80	Portland, Or.
14.2	·89	Breckenridge	−23			·47	Eastport	·67	do.
14.3	·87	Yankton	−10			·28	Halifax	·59	do.
15.1	·70	do.	−7			·19	do.	·50	do.
Jan. 20.3	·69	Father Point	3	40	Can.			·60	Cheyenne.
21.1	·74	Chatham	−7					·38	Fort Gibson.

Barometer above* 30·65 *inches.

No.	Date.	Barom.	Station.	Therm.	Wind preceding.	Originated where.	Low on East side. Bar.	Low on East side. Station.	Low on West side. Bar.	Low on West side. Station.
	1874.			°						
24	Jan. 23.3	30·71	Yankton	— 2	38	Can.	29·27	Cape Rosier		
	24.1	·86	do.	—17			·77	do.		
	24.2	·90	Cairo	36						
	24.3	·91	do.	28						
	25.1	·91	LaCrosse	3			·85	Eastport	29·95	Portland, Or.
	25.2	·81	Milwaukee	11			·79	Halifax	·86	do.
	25.3	·75	Port Stanley	3			·88	do.	·83	Fort Benton.
	26.1	·81	Memphis	41			·76	Sydney	·80	do.
25	Jan. 29.2	·80	Pembina	—18	47	Br.Col.	·88	Cape Rosier		
	29.3	·98	do.	—26			·98	do.		
	30.1	·77	do.	—22			·73	Halifax		
	30.2	·67	do.	—10					·69	Santa Fe.
	30.3	·66	do.	—21					·65	do.
	31.1	·69	Chatham	—35					·60	do.
	31.3	·69	Marquette	2					·64	do.
	Feb. 1.1	·79	Brockville	—25					·74	do.
	1.2	·84	Burlington	— 6						
	1.3	·87	do.	—13						
	2.1	·89	Chatham	—22						
	2.2	·76	Father Point	— 6					·98	Mobile.
	2.3	·73	Halifax	—10						
26	Feb. 5.1	·66	Brockville	— 8	30	Br.Col.	·59	Sydney	·63	Santa Fe.
27	Feb. 23.2	·72	Yankton	11	50	Br.Col.	·56	Quebec		
	23.3	·86	do.	— 2			·47	Father Point		
	24.1	·82	do.	— 1			·63	Sydney		
	24.2	·71	LaCrosse	5						
	24.3	·68	do.	3						
28	Mar. 23.1	·73	Breckenridge	— 8	48	Br.Col.	·47	Sydney		
	23.2	·67	do.	15			·38	do.		
	23.3	·71	Davenport	21			·49	do.		
	24.1	·70	St. Louis	23			·60	do.		
29	Apr. 12.1	·66	Alpena	18	32	Can.	·49	do.	·49	Fort Sully.
30	Sep. 17.3	·67	Cape Rosier	39	35	Br.Col.			·58	Fort Garry.
	18.1	·70	do.	47					·69	Leavenworth
	18.2	·66	do.	48					·49	do.
31	Oct. 12.1	·70	Yankton	16	37	Can.	·60	Cape Rosier	·95	S. Francisco
32	Oct. 30.3	·70	Fort Sully	16	41	Br.Col.	·47	Sydney		

These cases correspond to thirty-two different areas of high barometer, and thirty of these occurred during the six months from October to March, and none occurred during the four months from May to August. More than half of the whole number occurred during the months of December and January. Areas of unusually high pressure are thus found to occur at the same season of the year as areas of unusually low pressure.

In order to show how far these cases of high pressure are dependent upon latitude and longitude, I have divided the stations into three classes; one class including the stations east of longitude 86° from Greenwich; a second class including the stations between the meridians of 86° and 102°; the third class including the stations west of the meridian of 102°.

Classification of the cases of high pressure.

West of lon. 102°.			From lon. 86° to lon. 102°.			East of lon. 86°.		
Station.	**Lat.**	**Cases.**	**Station.**	**Lat.**	**Cases.**	**Station.**	**Lat.**	**Cases.**
Fort Benton	47° 52′	7	Pembina	49° 0′	9	Cape Rosier	48° 52′	4
Portland, Or.	45 30	1	Duluth	46 48	1	Father Point	48 31	4
			Marquette	46 33	1	Chatham	47 1	8
			Breckenridge	46 16	29	Quebec	46 48	1
			St. Paul	44 53	3	Sydney	46 8	1
			Fort Sully	44 39	8	Montreal	45 31	2
			LaCrosse	43 48	6	Alpena	45 5	1
			Milwaukee	43 3	1	Halifax	44 39	3
			Yankton	42 45	13	Brockville	44 31	2
			Chicago	41 52	2	Burlington	44 29	2
			Davenport	41 30	2	Kingston	44 12	6
			Omaha	41 16	1	Portland, Me.	43 40	2
			Leavenworth	39 19	6	Port Stanley	42 40	2
			St. Louis	38 37	1	Toledo	40 39	1
			Cairo	37 0	2	Baltimore	39 18	1
			Nashville	36 10	2	Lynchburg	37 18	1
			Fort Gibson	35 43	1	Norfolk	36 51	1
			Memphis	35 8	2	Knoxville	35 56	1
						Augusta	33 28	2
						Charleston	32 45	1

The observations at each of these stations cover the entire period of twenty-six months, with the following exceptions, viz., the observations at Pembina commenced in November, 1872; those at Halifax, in December, 1872; at Yankton and Fort Gibson, in April, 1873; at Chatham, in October, 1873; at Cape Rosier, Father Point and Sydney, in November, 1873; and at Brockville, in January, 1874. We see that cases of high barometer occur most frequently at the northern stations. About two-thirds of the whole number were north of latitude 44°, and only fifteen per cent of the whole number were south of latitude 40°. Only one of the cases occurred beyond the Rocky Mountains; and on the east side of the mountains high barometer is most frequent near the meridian 97°. After making allowance for the unequal period of observation at the different stations, we find that in the neighborhood of Dakota, cases of very high pressure are nearly twice as frequent as they are at a corresponding latitude near the Atlantic coast. This fact appears still more palpable if we make the comparison for pressures as high as 30·9 inches. In the region between longitude 86° and 102° the barometer rose as high as 30·9 inches in fifteen cases, while only one such case occurred in the district east of longitude 86°, and none occurred in the district west of longitude 102°.

The low temperature generally attending these high pressures is very remarkable. The lowest temperature observed in any case was −36° Fahrenheit at LaCrosse. In seven cases the ther-

mometer fell as low as $-30°$, and five of these cases occurred at Breckenridge. In more than half of the whole number of cases the thermometer fell as low as zero of Fahrenheit. The highest temperature reported in any one of these cases was 48° at Cape Rosier, September 18.2, 1874. This is a station where the daily range of temperature is unusually small, being influenced by the temperature of the Gulf of St. Lawrence. In all of these cases the average temperature at Breckenridge and its vicinity was very much lower than at any of the stations east of longitude 86°.

The fact that the region of lowest temperature is also the region of highest pressure cannot be regarded as accidental. The low temperature of the air increases its density, and thus contributes to increase its pressure. This point will be further considered on page 16.

With a single exception, these areas of high barometer appeared to come from British America. About half of them appeared to originate on the west side of the chain of the Rocky Mountains and half on the east side; but on account of the small number of stations of observation it is impossible to trace these areas of high pressure satisfactorily to their origin. Each area of high pressure appears to have commenced with a moderate elevation above 30·00 inches; this elevation gradually increased as the wave advanced, and generally attained its maximum over Dakota or Minnesota. In one case (Jan., 1873,) an area of high barometer prevailed in the Southern States which cannot be traced to British America. This area of high pressure seems to have been first developed in the neighborhood of Arkansas, and increased slowly in magnitude as it drifted eastward, attaining a height of 30·66 inches at Charleston, January 12th, 1873.

In nearly all of these cases an area of low pressure immediately preceded the area of high pressure. When the center of high pressure is west of the Mississippi, an area of low pressure is almost invariably indicated by the observations near the Atlantic coast. When the center of high pressure is near the Atlantic coast, there are no stations of observation where this low pressure on the east side could be shown, but generally an area of low pressure had prevailed in the same region a day or two previous. This was the case in Nos. 1, 10, 17, 21, 23 and 30. The only case in which an area of high pressure was not immediately preceded by an area of low pressure on the east side was No. 9. This case, which has already been referred to, apparently resulted from an area of low pressure prevailing in the northern part of the United States. We thus find that areas of very high pressure are almost invariably preceded by an area of low pressure on the east side, generally at a distance of about 1,200 miles.

Nearly all of these areas of high pressure were immediately followed by an area of low pressure on the west side. When the center of high pressure reached the middle of the continent, an area of low pressure was almost invariably indicated by the observations near the Pacific coast. As long as the center of high pressure was near the Pacific coast, there were no stations of observation where this low pressure on the west side could be shown, but generally an area of low pressure made its appearance in the same region within two days after the passage of the center of high pressure. Nos. 18, 19, 20, 27, 28 and 32 were of this kind.

The only cases in which an area of high barometer was not followed by an area of low barometer within two days, were Nos. 2, 3 and 5. In No. 2, an area of high barometer, which advanced eastward very slowly, was immediately succeeded by another area of high barometer, and no considerable low was formed between them within the limits of the United States, but a low was apparently formed in Canada. In like manner, No. 3 was immediately succeeded by another area of high barometer, and no considerable low was formed between them. In No. 5 a low area was apparently in process of formation on the west side, when another area of high pressure pushed in from the north and filled up the low area. Thus we see that an area of unusually high pressure is almost invariably succeeded by an area of low pressure on its western side, at a distance of about 1,200 miles, but occasionally a new area of high pressure pushes on immediately after the first, and prevents the formation of any considerable area of low pressure.

Areas of unusually high pressure are thus seen to be generally accompanied by areas of low pressure both on the east and west sides, and at an average distance of about 1,200 miles. Sometimes an area of high pressure is broad enough to cover the entire continent from ocean to ocean, as in November 17, 1872, January 24, 1874, February 1 and 2, 1874, and February 24, 1874; but generally when a center of high pressure is near the middle of the continent, an area of low pressure is found to be passing off on the east side, and another area of low pressure coming on upon the west side. This will appear from an inspection of the Table on pages 8, 9 and 10. Sometimes the same map shows an area of very high pressure in Minnesota, with areas of very low pressure both on the Atlantic and Pacific coasts. Such was the case December 23, 1872; December 26, 1872; January 27, 1873; March 4, 1873; November 29, 1873; January 15, 1874, and April 12, 1874. The case of January 15, 1874, is remarkable for the great difference between the maximum and the minimum pressures; and the case of April 12, 1874, is remarkable for the small distance between

the two centers of low pressure. Plate III represents the isobars for this date, and shows a maximum pressure at Alpena amounting to 30·66 inches, with a minimum on the east side of 29·49 inches at Sydney; and a minimum on the west side of 29·49 inches at Fort Sully.

The direction of the wind is shown by the arrows, and its force is shown by the number of feathers attached to the end of the arrow. One feather indicates a velocity not exceeding five miles per hour; two feathers indicate a velocity from six to ten miles; three feathers, from eleven to fifteen miles; four feathers, from sixteen to twenty miles, and so on for higher velocities.

Plate I accompanying my fifth paper represents an area of high barometer near the Mississippi River, with an area of low barometer in Oregon. There was at the same time an area of low barometer on the east side, which had just passed beyond the limits of the chart.

One of the most remarkable circumstances attending these areas of high pressure is the force of the northerly wind which precedes their formation. The following Table shows the direction and force of the wind (in miles per hour) at certain stations at the time of formation of each of the areas of high barometer mentioned in the Table on pages 8, 9 and 10.

No. 1.—1872, Oct. 27.1, Quebec, wind N. E. 33.

No. 2.—Nov. 12.2, Fort Sully, N. 40; Nov. 13.2, Breckenridge, N. W. 45; Nov. 13.3, Breckenridge, N. W. 40; Nov. 14.1, Fort Sully, N. W. 42; Breckenridge, N. W. 40; Nov. 14.2, Breckenridge, N. W. 36; Pembina, N. W. 30; Nov. 15.1, Breckenridge, N. W. 36; Pembina, N. W. 32; Nov. 15.2, Breckenridge, N. W. 47; Omaha, N. W. 30; Nov. 15.3, Pembina, N. W. 38.

No. 3.—Nov. 16.3, Breckenridge, N. W. 30; Nov. 17.1, Breckenridge, N. W. 28; Nov. 18.2, Fort Sully, N. W. 32.

No. 4.—Nov. 27.1, Grand Haven, N. W. 32; Milwaukee, N. W. 41; Nov. 29.2, Quebec, N.E. 57; Nov. 29.3, Quebec, N.E. 42.

No. 5.—Dec. 8.1, Quebec, N. E. 41; Dec. 8.2, Escanaba, N. W. 30; Dec. 8.3, Milwaukee, N. W. 30; Dec. 9.1, Milwaukee, N. 36; Dec. 9.2, Cape May, N. W. 36; Dec. 9.3, Philadelphia, N. W. 36; Dec. 10.1, New York, N. W. 36.

No. 6.—Dec. 20.1, Quebec, N. E. 33; Dec. 21.2, St. Louis, N. W. 38; Dec. 22.1, Cape May, N. W. 34.

No. 7.—Dec. 22.2, Breckenridge, N. W. 33; Fort Sully, N. 34; Dec. 22.3, Breckenridge, N.W. 40; Dec. 23.1, Chicago, N.W. 32; Grand Haven, N.W. 33; Dec. 23.3, Philadelphia, N. 32.

No. 8.—Dec. 26.1, Milwaukee, N. E. 30; Dec. 26.2, New London, N. 32; Dec. 26.3, New York, N. W. 30; Dec. 27.1, Milwaukee, N. W. 30; Dec. 27.2, Grand Haven, N. W. 30.

No. 9.—1873, Jan. 9.1, Breckenridge, N.W. 32; Fort Garry, N.W. 31; Pembina, N.W. 36; Jan. 9.2, Breckenridge, N.W. 35.

o. 10.—Jan. 12.3, Breckenridge, N. W. 40; Jan. 13.3, Kingston, W. 22.

o. 11.—Jan. 15.1, Breckenridge, N. W. 35; Jan. 17.1, Cairo, N. 38.

o. 12.—Jan. 27.2, Breckenridge, N. 40; Fort Sully, N. W. 32; Jan. 28.2, Oswego, N. W. 28.

o. 13.—Jan. 30.1, Fort Sully, N. W. 34.

o. 14.—March 1.2, Fort Garry, N. W. 23; March 1.3, Breckenridge, N. 25; March 2.1, Escanaba, N. 35; March 2.2, Escanaba, N. 32; March 3.2, Cape May, N. W. 32; Philadelphia, N. W. 30; March 3.3, Cape May, N. W. 36; Philadelphia, N. W. 30; Washington, N. W. 32; March 4.1, Cape May, N. W. 32; March 4.2, Cape May, N. W. 30.

o. 15.—March 24.2, Breckenridge, N. E. 30; March 24.3, Breckenridge, N. 30.

o. 16.—Dec. 1.1, Cape Rosier, N. W. 32.

o. 17.—Dec. 3.2, Yankton, N. W. 35; Dec. 3.3, Breckenridge, N. 28; St. Louis, W. 43; Dec. 4.1, Grand Haven, W. 49; Dec. 4.2, Milwaukee, N. 29.

o. 18.—Dec. 8.2, Yankton, N. W. 25; Dec. 10.1, Father Point, N. 25; Quebec, W. 54.

o. 19.—Dec. 18.2, Yankton, N. W. 26; Dec. 19.3, Cape May, N. W. 24; Quebec, N. E. 31.

o. 20.—Dec. 28.2, Fort Sully, N. W. 28; Dec. 28.3, Breckenridge, N. W. 29; Dec. 29.1, Grand Haven, N. W. 32; Dec. 29.2, Oswego, N. W. 28; Dec. 29.3, Grand Haven, N. W. 28; Erie, N. W. 28; Dec. 30.1, Erie, N. W. 28; Cape May, N. W. 28.

o. 21.—1874, Jan. 4.3, Toronto, N. W. 32.

o. 22.—Jan. 12.3, Fort Sully, N. 34; Breckenridge, N. 28; Jan. 13.1, Fort Sully, N. 28; Jan. 14.2, Eastport, N. E. 40; Quebec, N. E. 43; Jan. 14.3, Father Point, N. E. 30; Cape Rosier, N. E. 30; Jan. 15.1, Cape Rosier, N. E. 35; Jan. 15.3, Cape May, N. W. 32.

o. 23.—Jan. 18.2, Yankton, N. W. 40; Jan. 19.1, Escanaba, N. 28; Jan. 19.3, Oswego, N. E. 28; Jan. 20.1, Eastport, N. E. 28; Jan. 20.2, Sydney, N. E. 29.

o. 24.—Jan. 23.2, Philadelphia, N. W. 32; Jan. 24.2, Erie, N. W. 28; Saugeen, N. W. 34; Jan. 24.3, Albany, N. W. 31; Philadelphia, N. W. 30; Cape May, N. W. 38; Jan. 25.2, Oswego, N. W. 28; Eastport, N. 28; Jan. 25.3, Eastport, N. 28.

o. 25.—Jan. 28.1, Quebec, N. E. 47; Jan. 28 3, New York, N. W. 28; Jan. 30.2, Toledo, N. E. 28.

o. 26.—Feb. 4.3, Montreal, N. 26; Feb. 5.1, Eastport, N. 28; Feb. 5.2, Albany, W. 30.

o. 27.—Feb. 20.2, Fort Sully, N. 50; Breckenridge, N. 31; Feb. 20.3, Fort Sully, N. W. 30; Yankton, N. W. 26; Feb. 21.1, Yankton, N. W. 25; Feb. 22.3, Fort Sully, N. 36; Feb. 23.3, Albany, N. W. 34; Feb. 24.1, Norfolk, N. 26.

No. 28.—March 22.2, Detroit, N. W. 34; Escanaba, N. W. 32; Grand Haven, N. W. 36; Milwaukee, N. W. 32; March 22.3, Grand Haven, N. W. 31; Rochester, N. W. 34; Saugeen, N. W. 38; Toronto, N. W. 31; March 23.1, Albany, N. W. 25; Oswego, N. W. 28; Rochester, N. W. 25; Saugeen, N. W. 27; Toronto, N. W. 25; March 23.2, Albany, N. W. 34; Oswego, N. W. 28; Toronto, N. W. 29; Montreal, N. W. 27; Cape Rosier, N. W. 25; March 23.3, Burlington, N. W. 40; Cape May, N. W. 26; Father Point, N. W. 48; March 24.1, Eastport, N. 32.

No. 29.—April 12.1, Albany, N. W. 28; Burlington, N. 26; Eastport, N. 28; April 12.2, Cape Rosier, N. 30; April 12.3, Cape Rosier, N. 32.

No. 30.—Sept. 16.2, Quebec, N. E. 22; Sept. 17.1, Quebec, N. E. 35; Sept. 17.2, Quebec, N. E. 35.

No. 31.—Oct. 9.2, Bismark, N. W. 36; Fort Sully, N. 30; Pembina, N. W. 28; Oct. 10.2, Grand Haven, N. W. 32; Oct. 10.3, Parry Sound, W. 37.

No. 32.—Oct. 28.1, Bismark, N. 34; Oct. 28.2, Cheyenne, N. W. 40; Oct. 28.3, Yankton, N. W. 34; Breckenridge, N. 32; Oct. 29.2, Yankton, N. W. 28; Bismark, N. W. 37; Fort Sully, N. W. 32; Oct. 29.3, Fort Sully, N. W. 28; Quebec, N. 41; Oct. 30.1, Yankton, N.W. 28.

In column 6th of the table on pages 8, 9 and 10 is shown the highest wind which preceded each of these areas of high barometer. We see that these maximum velocities range from thirty to fifty-seven miles, the average being thirty-nine miles per hour. About two-thirds of all these violent winds were from the northwest, and all but six were from some northern quarter. These winds will be seen represented on Plate III.

The facts thus presented seem to confirm the conclusions stated in my eighth paper, and also to warrant some additional generalizations. We see that immediately after a center of low pressure has passed, the wind generally sets in with considerable force from a northern quarter. By the earth's rotation this northerly wind is deflected to the right, and thus is maintained a mechanical rarefaction of the air about the low center. The westward deflection of this current of air produces a mechanical condensation of the air on the western side, so that the same cause contributes to produce an area of low barometer on the east side and an area of high barometer on the west side, and the greater the force of this northerly wind, the greater will be the condensation of the air on the west side of the low area. Thus areas of unusually high barometer are in part the *effect* of the violent north winds which immediately precede them. These north winds come from a region having a very low temperature, so that the air is condensed partly by mechanical pressure, and partly by its low temperature. These northerly

winds push down with unusual force over Dakota and Minnesota, because during the winter months the coldest portion of the American continent is near this meridian, and the contrast between the temperature of Minnesota and that of the Gulf of Mexico is greater than is found for an equal difference of latitude east of the Mississippi.

These considerations do not explain the high barometer in the case of No. 9, and in similar cases which frequently occur in the Southern States; nor do they explain the long continuance which frequently characterizes these areas of high pressure. No. 14 presents a case in which an area of high barometer maintained itself for a week, with a very slow progress towards the southeast, and during all this time the air was blowing outward from the center of high pressure with a velocity of nearly ten miles per hour. This outward movement of the air would have levelled down the area of high barometer in a day or two, if the air thus drawn off had not been replaced from some other source. In the case of April 12, 1874, the outward movement of the air was nearly twenty miles per hour, yet this high area maintained itself for several days with but little diminution while it moved slowly towards the southeast. The supply of air requisite to maintain these areas of high pressure appears to come from the air which ascends from areas of low barometer; and since in the middle latitudes of North America the upper current is generally found moving from the northwest, the supply of air which maintains an area of high barometer, must come chiefly from an area of low barometer situated on its west or northwest side.

This conclusion is confirmed by the observations on the direction of the upper clouds made by the observers of the United States Signal Service, at the dates of the low barometer recorded in my eighth paper. In each of these cases when there was a well-defined area of high pressure on the east side of the area of low pressure within the limits of the United States, I selected all the cases in which the direction of the upper clouds was recorded at stations intermediate between the centers of low and high pressure. The results are given in the following table in which column first shows the date of the observation; column second shows the station; column third shows the direction of the surface wind, and column fourth shows the direction of the upper clouds at the given date and station.

It will be seen that the surface winds were in all cases blowing inward towards the low center, but inclined to the right; that is, they circulated around the low center, and at the same time moved spirally inward. The upper clouds were in all cases moving away from the low center and towards an area of high pressure on the east or southeast side. The movement of the upper clouds was sometimes directed almost exactly towards

Direction of the upper clouds between areas of low and high pressure.

Date.	Station.	Wind.	Clouds.	
1872.				
Dec. 24.1	Breckenridge	S.E.	W.	left.
1873.				
Jan. 29.2	Chicago	S.	W.	left.
Feb. 6.2	Breckenridge	S.W.	N.W.	left.
	Davenport	S.W.	N.	left.
Sept. 26.1	Marquette	S.E.	S.W.	left.
	Milwaukee	S.E.	S.W.	left.
	St. Louis	S.	W.	=
	Toledo	S.E.	S.W.	left.
26.2	Alpena	S.E.	S.W.	left.
	Cincinnati	S.E.	S.W.	left.
	Duluth	E.	S.W.	left.
	Port Dover	E.	S.W.	left.
	Toledo	S.	W.	left.
	Toronto	E.	W.	left.
	Washington	S.E.	W.	left.
Oct. 17.2	Cleveland	S.E.	W.	right.
	Louisville	S.	N.W.	right.
	Lynchburg	S.E.	N.W.	right.
Dec. 3.3	Buffalo	S.	S.W.	left.
	Cape Rosier	N.E.	W.	left.
Dec. 31.2	Fort Gibson	S.E.	N.W.	right.
	Indianapolis	S.E.	W.	left.
	LaCrosse	S.	N.W.	=
	Lynchburg	S.	N.W.	left.
	Marquette	S.	W.	left.
1874.				
Jan. 2.2	Breckenridge	E.	W.	left.
	Leavenworth	S.	N.W.	right.
	Memphis	S.E.	S.W.	left.
	Omaha	S.	W.	left.
	Pembina	E.	S.W.	left.
	Yankton	S.	N.W.	right.
Jan. 2.3	St. Paul	S.E.	S.W.	left.
3.1	Fort Gibson	S.E.	W.	=
	Memphis	S.E.	S.W.	left.
3.2	Cincinnati	S.	W.	left.
	Vicksburg	E.	S.W.	left.
16.1	St. Paul	S.E.	N.W.	left.
16.2	Escanaba	S.	N.W.	left.
	Memphis	E.	W.	right.
17.1	Oswego	S.E.	N.W.	left.
Feb. 11.2	Alpena	E.	W.	=
	Chicago	N.E.	S.W.	left.
	Davenport	S.E.	W.	right.
	Detroit	S.E.	W.	right.
	Escanaba	S.E.	N.W.	right.
	Fort Gibson	S.E.	W.	right.
	Grand Haven	S.E.	W.	right.
1874.				
Feb. 11.2	Omaha	S.	W.	right.
	Toledo	E.	W.	right.
11.3	Toledo	E.	W.	right.
12.1	Alpena	S.E.	S.W.	left.
	Cincinnati	S.E.	S.W.	left.
	Fort Gibson	E.	S.W.	left.
	Grand Haven	S.E.	W.	=
	Rochester	S.E.	W.	=
	Toledo	E.	N.W.	=
	Toronto	E.	S.W.	left.
12.2	Brockville	N.E.	W.	left.
	Oswego	S.E.	N.W.	=
	Washington	E.	W.	right.
Mar. 1.2	Albany	S.	W.	left.
1.3	Albany	S.	W.	left.
	Ottawa	S.	N.	=
6.2	Cincinnati	S.	N.W.	right.
	Memphis	S.E.	S.W.	=
6.3	Indianapolis	S.E.	S.W.	=
16.2	Alpena	S.E.	S.W.	left.
	Toronto	E.	S.W.	left.
Apr. 12.2	Cincinnati	E.	N.W.	right.
	Davenport	S.E.	W.	=
	Dubuque	E.	N.	right.
	Knoxville	E.	W.	right.
	Marquette	S.	W.	left.
	Memphis	S.E.	W.	right.
	St. Louis	E.	W.	right.
	St. Paul	S.E.	W.	left.
	Yankton	S.E.	N.W.	right.
12.3	Leavenworth	S.E.	S.W.	left.
30.2	Alpena	S.E.	N.W.	left.
May 8.2	Leavenworth	S.	N.W.	=
	Port Dover	S.	N.	=
	St. Paul	S.	W.	left.
	Toronto	E.	N.W.	left.
9.1	Fort Garry	N.E.	W.	left.
	St. Paul	S.	W.	left.
9.2	Fort Garry	N.E.	W.	left.
	St. Paul	S.	N.W.	=
27.2	Cairo	S.E.	S.W.	left.
	Escanaba	S.	W.	left.
	Fort Sully	S.E.	W.	left.
	Keokuk	S.	N.W.	right.
	Memphis	N.E.	W.	right.
	Milwaukee	S.E.	W.	left.
	St. Louis	S.E.	S.W.	left.
	St. Paul	S.	W.	left.

the center of high pressure; and such cases are designated by the character = in column fifth of the table. Sometimes the direction of the upper clouds was such as would carry them to the right of the high center; and such cases are designated by the term *right* in column fifth of the table. Generally, however, the direction of the upper clouds was such as would carry them to the left of the high center. Such cases are designated by the term *left* in column fifth of the table. We perceive that the movement towards the left of the high center is more than twice as frequent as towards the right; that is, while the movement of the upper clouds is from an area of low pressure towards an area of high pressure, there is a tendency to circulate around the high center in the same direction in which the surface winds circulate around a center of high pressure. Thus we see that near the earth's surface there is a steady but circuitous movement of the air from an area of high barometer towards an area of low barometer where the air ascends, and thence by a retrograde movement it returns to some area of high barometer (perhaps the same one from which it started), where it descends to the surface of the earth and again repeats the same or a similar movement.

A similar circulation of the air is indicated by the observations of temperature at Iceland when compared with observations in Central Europe.

In my fifth paper, page 7, I have shown that according to observations of fifteen years, a temperature *above* the mean in Iceland is generally accompanied by a temperature *below* the mean in Central Europe, and the contrast is most decided during the colder months of the year. I have recently received the Journal of the Scottish Meteorological Society, vol. iii, N. S., which furnishes the mean temperature of each month in Iceland, from November, 1845, to December, 1871, a period of twenty-six years, and I have compared the temperature of each month with the average temperature of that month for the entire period. In the Sitzungsberichte der Akademie der Wissenschaften zu Wien, December, 1866, is given the mean temperature of each month at Vienna, from 1775 to 1864, together with the difference between the temperature of each month and the mean temperature of that month as derived from observations of ninety years. The temperature of Vienna from 1865 to 1872, is given in Jelinek's Jahrbücher für Meteorologie, 1871, page 189. Upon comparing the departures from the mean temperature at Iceland and Vienna for these twenty-six years, we obtain nearly the same result as had been previously deduced from observations of fifteen years. The following table shows the comparison for three months, November, December and January, for the entire period of forty-one years. Column second for each month shows *all* the cases in which the

temperature at Iceland was at least 2½ degrees Fahrenheit (one degree Reaumur) above the mean, and the year is shown in column first. Column third shows how much the temperature at Vienna for the same month was above or below the mean.

Temperature of Iceland and Vienna compared.

November.			December.			January.		
	Iceland.	Vienna.		Iceland.	Vienna.		Iceland.	Vienna.
1827	+5°·1	−7°·1	1826	+2·°6	+ 4°·3	1823	+4·°1	−10°·2
32	2·7	−3·0	28	6·2	+ 3·7	28	4·5	+ 0·4
35	3·6	−8·0	29	4·1	−13·4	29	2·3	− 3·7
46	5·0	−3·8	31	3·2	− 0·3	30	4·3	−11·9
51	2·9	−4·5	34	6·1	+ 3·1	33	3·1	− 7·5
55	3·6	0	35	2·9	− 4·0	47	9·9	− 3·7
57	5·3	−3·5	49	5·0	− 3·4	48	2·5	−11·0
58	2·5	−8·1	50	5·9	+ 0·7	51	5·5	+ 0.9
64	4·3	−1·8	51	7·0	+ 0·1	61	5·3	− 3·6
67	3·5	−1·8	53	5·2	− 8·4	62	3·9	− 1·6
70	2·7	+4·8	58	2·9	+ 0·9	64	3·4	− 9·0
Mean	+3·7	−3·4	61	3·5	− 2·7	69	5·1	− 0·2
			64	3·0	− 6·6	70	2·9	+ 0·4
			75	3·6	+ 1·1	Mean	+4·4	−4·7
			67	2·3	− 1·1			
			71	3·4	−10·1			
			Mean	+4·2	−2·3			

November.			December.			January.		
1827	+5·1	−7·1						
29	+0·1	7·7				1823	+4·1	−10·2
32	+2·7	3·1	1829	+4·1	−13·4	26	−0·4	8·2
35	+3·6	8·0	32	−0·6	3·0	29	+2·3	3·7
46	+5·0	3·8	35	+2·9	4·0	30	+4·3	11·9
47	−2·7	2·8	46	+0·9	3·3	31	+0·6	3·2
49	−0·2	2·7	49	+5·0	3·4	33	+3·1	7·5
51	+2·9	4·5	53	+5·2	8·4	47	+9·9	3·7
53	+1·2	2·5	55	+0·9	10·8	48	+2·5	11·0
54	−0·6	3·6	59	−6·0	6·1	50	+1·4	6·6
56	−0·7	6·3	61	+3·5	2·7	58	+0·7	3·1
57	+5·3	3·5	64	+3·0	6·7	61	+5·3	3·6
58	+2·5	8·1	70	+2·1	5·4	64	+3·4	9·0
60	+1·8	3·3	71	+3·4	10·1	71	+1·6	5·1
Mean	+1·9	−4·8	Mean	+2·0	−6·4	Mean	+3·0	−6·7

It will be seen that for the years here named, the average temperature of Iceland in November was 3·7 degrees (Fahrenheit) above the mean, while that of Vienna was 3·4 degrees *below* the mean; and for the three months compared, the temperature of Iceland was 4·1 degrees above the mean, while that of Vienna for the same months was 3·5 degrees *below* the mean. Now if the temperature of Vienna were independent of the causes which affect the temperature at Iceland, the average departure from the mean temperature at Vienna for the months in question should be *zero*, instead of which we find the value 3·5 degrees.

In the lower half of the table, column third contains all the cases in which the temperature at Vienna was at least 2½

degrees (Fahrenheit) *below* the mean, and column second shows how much the temperature at Iceland was above or below the mean for the same months. It will be seen that for the years here named, the average temperature at Vienna in November was 4·8 degrees below the mean, while that of Iceland was 1·9 degrees *above* the mean; and for the three months compared, the temperature at Vienna was 6·0 degrees below the mean, while that of Iceland was 2·3 degrees *above* the mean. If the temperature at Iceland were independent of the causes which affect the temperature at Vienna, the average departure from the mean temperature at Iceland for the months in question should be *zero*, instead of which we find the value 2·3 degrees. Considering that these are the average results derived from forty-one years of observations, I think it is established that when the temperature of Iceland during the colder months of the year is much *above* the mean, the temperature at Vienna is generally depressed *below* the mean.

It will be noticed that exceptions to this rule do occasionally occur. Thus in December, 1826, '28 and '34, and in November, 1870, the temperature was unusually high both at Iceland and Vienna; also in November, 1847, and December, 1859, the temperature was unusually low both at Iceland and Vienna. In December, 1826 and '28, the temperature was above the mean over nearly the whole of Europe, but in Sicily it was somewhat below the mean. In December, 1834, the temperature was considerably below the mean in Switzerland and Northern Italy; and in November, 1870, the temperature was below the mean in England. In November, 1847, although the temperature was below the mean both at Iceland and Vienna, it was very much above the mean at St. Petersburgh, and throughout a considerable portion of Northern Europe. In December, 1859, the depression of temperature was widely extended, but I have not been able to determine whether it reached to all parts of Europe.

The preceding facts seem to confirm the conclusions which I stated in my fifth paper, that an area of low barometer in Iceland, is usually accompanied by an area of high barometer in Southern or Southeastern Europe, and that during the colder months of the year, Vienna is generally near the center of this high area. I infer also that this area of high pressure is replenished by air which rises from the area of low pressure. This air which ascends near Iceland travels as an upper current towards the southeast, and hence the average direction of the upper current in Europe during the winter months is from about N. 52° W. to S. 52° E.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College, of the class of 1871.

Art. II.—*On Acoustic Repulsion*; by V. Dvořák.

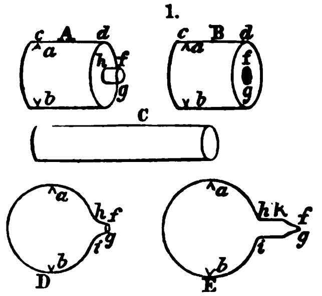
(Translated from Annalen der Physik und Chemie, Band III, No. 3. Dated Agram, 19th November, 1877. With a note by Alfred M. Mayer.)

(1.) *Acoustic repulsion of resonators which are open at one end only.*—In a previous article "On Acoustic Attraction and Repulsion," I have conclusively proved by theoretic considerations as well as by experiments, that the average pressure at the node in a column of air vibrating in stationary waves cannot be equal to zero as long as the amplitude of vibration is not infinitely small.

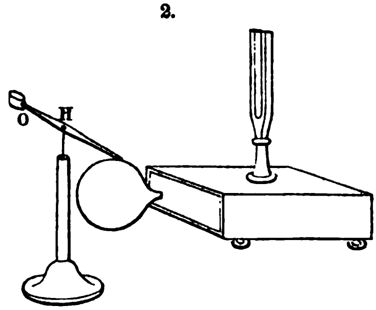
In a resonator, open at one end, as for example a cylinder, we find a node at the closed end. In the interior of the cylinder near its closed end there exists a greater pressure than on the outer surface of this end which is touched by the outside air, as can be easily shown by means of a sensitive manometer.

To obtain resonance the opening of the cylinder is turned toward the source of the sound, and the cylinder is then repelled by the excess of pressure within. Resonators not having a cylindrical form, but open at one end, are also subject to such repulsion. In my previous communication I have indicated means for observing the acoustic repulsion of resonators.

1.



2.



As the method described there is not very sensitive, I have replaced it by the following. The resonators here employed are usually made of stiff drawing paper covered with gum Arabic and have the shape of the cylinder with a little paper tube *h f*, at one end; fig. 1, A. This little tube may also be omitted as in fig. 1, B; in that case the resonator is tuned by increasing or diminishing the little opening, *f g*. Even a cylindrical tube open at one end, fig. 1, C, may serve our purpose as a resonator. Spherical resonators of glass, fig. 1, D, which a practiced glass-blower can make as light as paper resonators, are excellent. The note of the resonators is determined by gently blowing over the opening or by tapping.

The resonator is fastened with sealing wax to the end of a light wooden rod, the other extremity of which is provided with a counterpoise of lead O, fig. 2. The center of the rod has a glass cap, H, which rests on a needle point.

The best source of sound is a resonant box of a tuning fork, fig. 2. The repulsion is so great that it is apparent even with an ordinary brass Helmholtz resonator, weighing, with the lead counterpoise, 142 grams.* With every tuning fork we must first ascertain whether the air in the resonating box vibrates with sufficient energy, because this is not always the case even with accurately tuned boxes. As the elasticity of the different boards which form the elastic system of the box is not equal, their vibrations may hinder the formation of the node at the bottom of the box; in this case the air on the bottom of the box will vibrate but feebly. We can easily ascertain this fact by accurately tuning the box to the note of the fork and then observing whether the note is considerably weakened by partially covering the opening. If it is not, then the air in the box has but little vibration even if the tone of the fork is powerful. I have, for example, two boxes with excellent tuning forks by König (of 256 vibrations per second), in which the air would in nowise vibrate powerfully. The strength of the vibration of the air was considerably affected by the degree of tightness with which the fork was screwed to the top of the box. The fork is always vibrated powerfully with a bow, and two bits of rubber tubing must be on the bottom of the box. I generally use the fork A_3, of 435 vibrations per second, by König. Repulsion is then plainly visible with glass resonator at a distance of ten centimeters from the opening of the box. With a large C fork of König (of 128 vibrations) which sounds for more than ten minutes, it was apparent at a distance of twenty centimeters.

The resonators may be tested either by the reinforcement of the sound produced with a tuning-fork, or by the weakening of the sound on approaching them to the opening of the box.† It is not possible to obtain the repulsion of resonators from the prongs of a tuning fork alone, as their aerial vibrations are too weak. (Compare Pogg., clvii, p. 42). I formerly tried in vain to obtain acoustic repulsion from vibrating bodies without the aid of resonance. I suspended small resonators before the end of a glass tube vibrating longitudinally and provided with a cork to increase the vibrating surface. The open end of the resonator was probably too near the end of the fork, and so produced a lowering of the tone and acoustic attraction instead of repul-

* The apparatus represented in fig. 3 may be also used to show acoustic attraction by turning the closed end of the resonator toward the box.

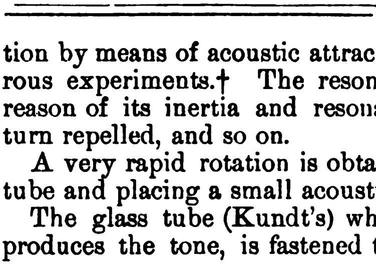
† This is perhaps connected with a conversion of the aërial vibrations in the box into the work of repulsion. The *vis viva* of the sound-vibrations disappears to re-appear as work.

sion. Attraction is probably present in all cases and can assert itself only when not counteracted by greater repulsion.* Later I obtained repulsion very easily in a longitudinally vibrating glass tube 127 centimeters long and 27 millimeters in diameter, on the end of which was a cork 46 millimeters in diameter. One of the resonators used was spherical, fig. 1, B, and another cylindrical, C.

I also obtained powerful repulsion with a circular disk 31 centimeters in diameter and 2 millimeters thick, made by König. The plate was fastened in the center in a vertical position and made to vibrate in six segments, producing a note of 208 vibrations. The resonator was made of stiff paper of the form of B, fig. 1; *a b* equal 80 millimeters, *c d* 140 millimeters, *f g*, equal 17 millimeters, and its opening was placed in front of the center of a vibrating segment, or ventre.

(2.) *The Acoustic Mill.*—A continuous rotation is easily obtained on the principle of the acoustic repulsion of resonators by fastening four very light paper or glass resonators upon two wooden rods, *o*, *p*; *r*, *q*, fig. 3, crossing at right angles, and balanced on a glass cap. All the openings of the resonators fronting one side in the direction of tangents. The whole apparatus is placed before the opening K of the resonating box and fork, in the manner indicated in fig. 3. The open end *a* of resonator, 1, is repelled from K; the closed end B of resonator 2, is attracted, but in general this attraction does not increase the rapidity of rotation, because it counteracts rotation the moment the resonator, 2, has changed its position about 45°. It is therefore not possible to obtain continuous rotation by means of acoustic attraction, as I have shown by numerous experiments.† The resonator, 1, continues to move by reason of its inertia and resonator 2 takes its place, being in turn repelled, and so on.

3.



A very rapid rotation is obtained by using a large Kundt's tube and placing a small acoustic mill before its open end.

The glass tube (Kundt's) which vibrates longitudinally and produces the tone, is fastened to a heavy table, and protrudes

* These experiments were also described in a previous communication. In the apparatus represented, fig. 2, repulsion is easily converted into attraction by diminishing the opening of the resonator with wax, and so throwing it out of tune.

† Instead of the resonators, fig. 3, I used vertical paper vanes, varying the curvature without achieving any results, notwithstanding the fact that there was a pretty strong acoustic attraction for each separate vane.

only a short distance through the cork into the glass tube, placed upon a separate table so that its open end projects somewhat beyond the edge of the latter. The length of the rod was 127 centimeters, the diameter twenty-seven millimeters; the half wave length of its note, $\frac{\lambda}{2}$, equals ten and one-half centimeters. The length of the tube was 45 centimeters, the length of the vibrating column of air, corrected for the open end, was $3\frac{\lambda}{2}+\frac{\lambda}{4}$; the inner diameter was five centimeters.

(3.) *The Acoustic Torsion Balance.*—If we hang by a wire a wooden rod provided with a resonator, like the beam of a Coulomb's torsion-balance, in a case having an opening in the side turned toward the resonator, we can compare the intensity of notes having an equal number of vibrations by means of the repulsion of the resonator; but further experiments are necessary to test the practicability of this method. The sound proceeded from an open pipe, having the note A (of 435 vibrations). To prevent the current of air which passes through the pipe from striking the resonator attached to the balance, we must cut the pipe exactly in the middle of its node, and insert a slack membrane softened with glycerine. To prevent the air, issuing from the mouth of the pipe, from impinging on the resonator, a broad box is used which surrounds the mouth of the pipe air-tight. This box is open on the side opposite the resonator so as not to impair the tone. The pipe is sounded by means of a König's acoustic bellows with a uniform blast of air. The distance of the resonator from the mouth of the pipe must be at least two or three centimeters, to avoid a change of pitch.

(4.) *Production of aerial currents by Sound.*—It may easily be proved by simple theoretic considerations that the mean pressure at the node of a column of air is greater than at its ventre, and that it steadily diminishes in passing from the node to the ventre, provided that the amplitude of vibration is not infinitely small.

It would seem that this difference of pressure would be neutralized by the passage of the air from the node to the ventre. There would then be produced a mean pressure in the whole column, which would be greater, however, than that of air at rest. Consequently air would issue from the opening of the vessel in which it forms stationary waves. I have not succeeded so far in making the whole process clear, for in reality no perfect balance of pressure takes place. The manometer always shows a slight excess of pressure even at the ventre, but this excess increases as we pass to the node. All my previous experiments indicate moveover that a current of air

passes from the node to the ventres, at least in Kundt's tube, in which the air waves are very powerful. This *principal current* lasts as long as the air vibrates. Besides, the same experiments show a continuous secondary current, close to the walls of the tube and in a direction contrary to that of the principal current, so that the whole air in the tube is in circulation. The cross section of the principal current is nearly as great as that of the tube, while that of the secondary current is a very narrow ring.

The excess of pressure as shown by a manometer at the node is always less than the theoretical pressure, because in the latter the air is not supposed to move from the node and to equalize the pressure. Of course the excess of pressure at the ventre is not equal to zero, as theory requires. Probably the friction of the walls has much to do with these phenomena. It may be expected from what has been said that the air will issue from the vessel in which it vibrates in stationary waves. The manometer shows in the first place that the excess of pressure is not equal to zero in the plane of the opening of a resonator because a portion of the air immediately in front of this opening partakes of this stationary wave motion, and because there is always a small excess of pressure even in the ventre of a stationary wave. There is no doubt that a partial equalization of pressure takes place at the opening; experiments show, furthermore, that there is a continuous exit of air which, as in Kundt's tube, is probably neutralized by a secondary and contrary current.

The exit of the air can easily be proved, as follows: a spherical glass resonator is placed before the resonant base of a tuning fork, the resonator is filled with tobacco smoke, strong vibrations are given to the fork, when the smoke will be seen to rush from the resonator.

The current of air proceeding from a resonator is well shown by means of a Chladni plate, by means of lycopodium, which accumulates upon the ventres in little heaps when the plate is sounded. If now we place the opening of a bottle, or bottles of a resonator, B, over such a heap, the lycopodium is immediately blown about in a circle and may be scattered in any direction by giving suitable inclinations to the resonator. A glass plate held over a heap of lycopodium produces the opposite effect by causing it to contract.

I have succeeded in producing comparatively strong currents of air in still another manner, but I have not yet found an explanation of these complicated phenomena.

A cone made of stiff paper was held with its large end opposite the opening of a large Kundt's tube. The size of this cone may vary, but its effect is greatest when it vibrates to the same note as the Kundt's tube, and so forms a resonator open

at both ends; the diameters of its open ends are thirty-seven and seven millimeters and its length ninety millimeters.

When the Kundt's tube begins to sound loudly a current of air issues from the narrow end of the cone with such violence that it easily blows out of the flame of a candle at a distance of twenty centimeters. This current rushes through the cone with a peculiar noise and is easily felt with the finger.

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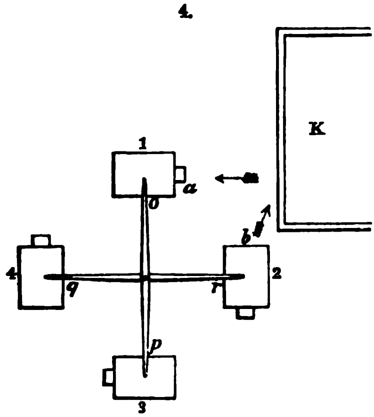

The cone may be replaced by a cylinder having the width of the Kundt's tube, open at the end turned toward the latter, and closed all but a small hole at the end, but the current is much weaker, nevertheless it will move a small wheel with vertical paper vanes, fig. 4.

In the experiments with the tuning forks, it is essential that the cone should vibrate to the same note as the fork, otherwise the current is too weak. For the fork A (of 435 vibrations), the openings of the cone have diameters of 82 and 3 millimeters, and the length 373 millimeters. The opening at the apex of the cone must be very small to obtain an appreciable current.

On conclusion of this investigation, Dr. R. König kindly communicated to me that Mr. Alfred Mayer in New York [Hoboken] had previously succeeded in producing continuous rotation by means of sound. The communication was as follows: "Professor A. M. Mayer showed me a very similar experiment last summer (1876). He suspended by a thread two large well-tuned flasks attached to a rod, and caused the whole apparatus to revolve by means of a tuning fork. I informed him in consequence that you had previously demonstrated the phenomena of repulsion in resonators, for he was not acquainted with your paper* on acoustic attraction and repulsion."

NOTE BY PROFESSOR ALFRED M. MAYER.—My connection with the discovery of the Sound-Mill is as follows:

In January, 1876, I made the discovery—first reached by theoretic deductions—that there was more pressure on the inner surface of the bottom of a resounding cavity than on the outer surface of the bottom which touches the outer air. I subsequently proved the truth of this conclusion by experiments on suspended resonators and by observations on the

* Read before the R. Acad. Sci., Vienna in 1875.

motions of precipitated silica powder and films of soap-bubbles placed at various points in resonators of different forms. My first publication of these results was on May 22d, 1876, on which day I read a paper on this discovery before the New York Academy of Sciences, and exhibited before the members an apparatus formed of two + arms of light wood, with a resonator attached to each arm, as in fig. 3 of Professor Dvorák's paper. On sounding an organ-pipe, or a fork on its resonant box, in tune with these resonators, they were successively repelled from the pipe, or fork, and a continuous rotation was exhibited. At the same meeting this experiment was preceded by those on the motions of silica powder, etc., in resonators.

On the 8th of July, 1876, there appeared in the Scientific American a report of this meeting of the Academy, in which my experiments in Acoustic Repulsion are thus referred to:

"In the next place, Professor Mayer exhibited an apparatus constructed by him to produce motion by means of sound pulses. Four glass resonators on cross arms were suspended by means of a string. On sounding an organ-pipe in tune with the resonators, and bringing it opposite the mouth of one of them, the resonator was repelled and the apparatus commenced to rotate. This experiment was the more striking from the fact that, so far from any current of air proceeding out of the mouth of the organ-pipe, the air is actually sucked in, as may be rendered visible by means of smoke from a cigar. The smoke is carried up the pipe even when the latter is closed at the top with cotton wool so as to smother the sound. On substituting disks of cardboard for the resonators, they were drawn up to the mouth of the organ-pipe with considerable force. When fine silica powder was placed in the resonators, it was thrown into violent motion on sounding the pipe."

In the same month, July, 1876, Dr. Rudolph König visited me, and I exhibited the same experiments before him.

The discovery of the acoustic repulsion of resonators and the invention of the sound-mill were made independently by Professor Dvorák and myself. It is another instance of men—even so far distant as Agram and Hoboken—led into the same path of research by the natural growth of science.

Dimensions of the resonators and reaction-wheels used, in millimeters: (1) Fork C, of 128 vibrations. Glass resonator of form E, fig. 1, *a b*, equals 90; *h i* 25; *h k* 20; *k f* 33, *f g* 8. Its weight, together with its leaded counterpoise, was 70 grams.

(2) Fork A, 435 (vibrations per second). (*a.*) The glass resonator used in the experiment represented in fig. 2, and to

show the current of air by means of smoke, was of the form D, fig. 1. *a b*, equalled 58, *h f* 22; *f g* 10. (*b*.) The glass resonators of the acoustic mill were of the form D. *a b* equals 34; *h f* 12; *f g* 3. The length of the arms from the middle of the glass caps to the middle of the resonator was 52 millimeters. The weight of the whole wheel was 23 grams. (*c*.) Paper resonators of the acoustic mill, fig. 3, were of the form A, fig. 1. *a b* equals 34; *c d* 50; *h f* 6; *f g* 9 millimeters. The length of the arms was 65; the weight of the whole wheel 9 grams.

(3.) Kundt's tube, $\frac{\lambda}{2}$ equals 105 millimeters. The glass resonators of the acoustic mill were of the form D, fig. 1. *a b* equals 24; *h f* 2; *f g* 7; length of the arms 30 millimeters.

It is a striking fact that very small resonators may give a very deep note; with fork A, I used a glass resonator of the form D, fig. 1, in which *a b* equals 24; *h f* 14; and *f g*, 1 millimeter. The volume was about ninety times less than that of the resonant box of the fork, to whose note the resonator was tuned. Notwithstanding its smallness it showed acoustic repulsion.

ART. III.—*On certain artificial crystals of Gold and Gold Amalgam*; by ALBERT H. CHESTER.

IN casting bars of pure gold for the manufacture of foil, traces of crystallization may often be observed upon their upper surfaces, and sometimes distinct crystalline forms. These are generally simple triangular faces slightly raised, very similar in appearance to specimens sometimes found in nature. Occasionally several faces of the octahedron may be seen, the edge in some instances being half an inch in length, and quite sharp and well defined. The purer the gold is, the more likely the crystals are to form, and they are oftenest seen when the bars are cast from that which has been previously crystallized by the battery process described below. The presence of a very small amount of copper seems to prevent it entirely, and the surface of the bar is quite smooth. It is perhaps worthy of notice that the forms observed are always triangular and never hexagonal, as is so frequently the case with natural crystals of gold. They do not seem to be distorted or flattened at all. Neither do the dendritic forms so common in nature and now quite easily obtained artificially, appear on the surface of the bars.

The precipitation of gold from solution by the aid of a battery is a well known process in the common operation of

electro-gilding, but to deposit it in the crystalline form is a process of comparatively recent date, having been patented in 1860, as a method of preparing gold for dental purposes. The process is briefly as follows. A solution of chloride of gold and ammonium is placed in a shallow dish coated with heavy gold foil, which is connected with the zinc plate of a large Daniells' battery. Near the top of the solution and connected with the copper plate of the battery, a roll made up of thin strips of pure gold is suspended, enclosed in a muslin bag. The strength of the battery current is controlled by a coil of wire arranged as a rheostat, a clamp terminating one of the battery wires enabling the operator to include a greater or less number of coils in the circuit. The necessary conditions being fulfilled, on completing the circuit the gold is gradually dissolved from the roll and deposited on the bottom of the dish in bright crystalline flakes, having the appearance of feathers or fern leaves when examined under the microscope. Fig. 1 shows one of these crystals magnified one hundred and fifty diameters. At first sight this appears to be like certain natural crystals occasionally found, and the arborescent forms of other isometric minerals. But all such crystals that I have seen have invariably the angle of 60° between the side ribs and the midrib, making an angle of 120° between the two sets of ribs. Gold, silver and copper all show this characteristic, which is particularly well illustrated in the crystals described by Professor Vom Rath in the last volume of Groth's Zeitschrift für Krystallographie. It is quite difficult in the case of these artificial crystals to measure their angles, because the midrib is usually more or less curved, and the whole form presents great irregularities. It can only be done approximately for a single crystal, but by making a large number of measurements this difficulty may be in part overcome. The figure above shows a crystal much like the natural ones, the angle on the left of the midrib being about 59° and on the other side 61°. This is an unusually regular one, though I have noticed one still more so, the angles of which measure respectively 60° 36′ and 62° 6′. Fig. 2 represents a crystal such as is most often seen, where the angle on one side is 41° and on the other 79°. The average of fifty measurements of these crystals taken at random is on one side 44° 38′ and on the other 75° 47′. Nineteen measurements made at another time made the two angles 42° 18′ and 78° 24′. The

1.

2

smallest angle noticed was 30° 36′. The following table of several consecutive measurements shows how wide the variation is, the last column giving the total angle between the sets of ribs.

30° 36′	89° 30′	120° 6′
41° 54′	78° 18′	120° 12′
46° 48′	73° 48′	120° 36′
35° 36′	84° 24′	120° 0′
53° 42′	64° 48′	118° 30′
49° 0′	73° 36′	122° 36′
38° 0′	81° 6′	119° 6′
49° 42′	69° 54′	119° 36′

It is noticeable that the same angles are carried out in each crystal, no matter how many branches it may have, and the crystal shown in fig. 2 was selected to illustrate this fact.

I have been quite surprised that no trace of faces is to be observed upon these crystals, as is always the case with natural ones. The latter are seen under a low power to be made up of strings of distorted isometric crystals which are often so distinct that they can be measured. The artificial ones do not show this structure, and when magnified to 300 diameters only show a slightly beaded look along the side ribs, but nothing that can be considered distinct crystalline forms. With the power mentioned the whole surface of each crystal is in focus at once, showing that the different sets of ribs are in the same plane. Fig. 2, with all its branches, was drawn complete without altering the focus of the instrument. Where one crystal lies upon another, when examined under a power of 150 diameters, both are in focus at once, showing that they are exceedingly thin and lie perfectly flat. The power above mentioned, 300 diameters, is the highest with which I have examined them. Possibly with a higher power they might be resolved, and show what is their crystalline form. That they are isometric there is no doubt.

If a film of amalgam is allowed to form on the surface of a piece of pure gold, and the mercury be then driven off by heat, traces of crystallization may sometimes be observed, a network of indistinct crystals remaining. To accomplish this the gold should be perfectly pure, and the heat applied very gently at first. With the greatest pains, however, the result is not always, or even often, satisfactory. The surface is generally left in an amorphous condition, or at best covered with angular depressions. Very rarely, and under conditions not fully understood, the crystallization is distinct enough to be recognized as such. But distinct though minute crystals of gold amalgam may easily be obtained if the mercury is dissolved out with dilute nitric acid, instead of being driven off by

[illegible]. A series of measurements on a number of these crystals proves them to belong to the hexagonal system, having in general the form shown in fig. 3. The average of forty-eight measurements of the pyramidal angle is [illegible]; the six angles of the most perfect one found measuring as follows: [illegible] 36′ and [illegible]. The angle O ∧ 1 has been approximately determined to be about 136°, the roughness of the crystals rendering exact measurements extremely difficult. The pyramidal planes are sometimes entirely wanting, the crystal having only a basal termination. The base is often hollow, in one crystal presenting the appearance shown in fig. 4, the whole base being gone. The sides and bottom of this depression are quite rough and show no attempt at regularity. Another termination is shown in fig. 5, where part of the base still remains. Fig. 3 was drawn under a power of 300 diameters, the general shape being retained but the irregularities taken away. It is about 0·5 mm. in length and 0·06 mm. in diameter. The gold used in preparing these crystals should be pure and in a finely divided condition. I prefer gold precipitated from solution by ferrous sulphate, washed with dilute chlorhydric acid and then with water and dried. This should be treated with about twelve parts of mercury and well triturated in a mortar. The amalgam must then be heated to about 150° C., kept at that temperature for about five minutes, and then allowed to cool gradually. After this it should remain at rest for twelve hours or more. The amalgam, which should be quite fluid, is now to be digested in nitric acid, first of 1·2 sp. gr., and after of 1·4, heating very gently at the beginning, but toward the close of the operation raising it to boiling. The mass left undissolved consists of minute crystals resembling gold in color, but a little darker and having a greenish tinge. They are quite brittle and break with a slight touch. They contain about six per cent of mercury, which may be driven off without injuring the crystals by heating them for a short time to a dull red. The mass will then take the color of pure gold, becoming somewhat spongy, and lose entirely its brittle character. This process was patented in 1853, and used for some time in the preparation of gold for filling teeth, making what was called sponge or crystal gold.

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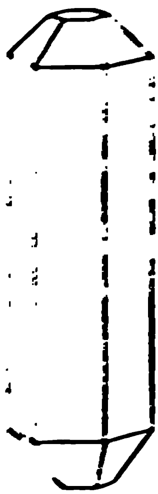

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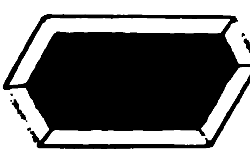

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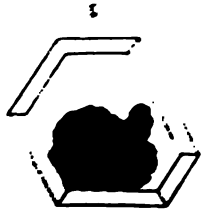

Hamilton College, April 4th, 1878.

ART. IV.—*On a new and remarkable mineral locality in Fairfield County, Connecticut; with a description of several new species occurring there;* by GEORGE J. BRUSH and EDWARD S. DANA. First Paper.

Historical Note.

THE new locality of manganesian phosphates, which we shall describe in this and following papers, is situated near the village of Branchville, in the town of Redding, Fairfield County, Connecticut. Its remarkable character will be evident from the statement that we have thus far discovered, among the material which we have obtained from there, no less than six new and well defined species, besides many other known species of more or less rarity.

The locality was first opened some two years since by Mr. A. N. Fillow, upon whose land it is situated, and who made considerable excavations in the search for mica of commercial value. Only a limited quantity of this was obtained, so that the work was finally discontinued and the opening filled up; by which means the ledge was buried under six to eight feet of soil. With most commendable thoughtfulness, however, he laid aside and preserved a large number of specimens which seemed to him to be of some interest. In the latter part of the summer of 1877, Prof. Dana visited the region and his attention was called by Mr. Fillow to the collection of minerals mentioned, and by him several specimens were brought to New Haven. Later, Rev. John Dickinson of Redding, the adjoining village, happened to visit the locality and obtained a considerable amount of the minerals, some of which he sent to New Haven for determination. It was not, however, until the early spring of the present year that we were able personally to visit the locality. Appreciating then the unusual interest connected with it, we immediately made arrangements with Mr. Fillow to uncover the ledge and to go forward with the exploration as thoroughly as possible. We have now pushed the matter as far as is practicable for the present, but later in the season we hope to accomplish more. The result of our work has been to place in our hands a large amount of material, in the examination of which we are at present engaged, and we are now ready to make public* a portion of the results. In addition to the material we have personally obtained, we have, through the liberality of Mr. Dickinson, come into the possession of a large number of additional specimens collected by

* Short notices of the new species eosphorite, triploidite, dickinsonite, and lithiophilite (by mistake printed *lithiolite*) were published on pp. 398, 481, of the preceding volume.

himself before our first visits to Branchville. These have been of the greatest service to us in the study of the species occurring at the locality, and we would here express our great appreciation of his generosity. We would also mention our obligations to Mr. Fillow and his brother, who have been most careful in obtaining the best results possible in the explorations of which they have taken charge.

Brief general description.

All the minerals which we have obtained are from a single vein of albitic granite, and the line along which the explorations have been carried does not exceed twenty feet. The general description of the vein and of the minerals which compose it—with the exception of the manganesian phosphates and the immediately associated species—we reserve for a later paper; we will mention, however, that outside of these we have identified the following species:—

Albite, quartz, microcline in large masses, a hydro-mica near damourite having a peculiar concentric spherical structure, spodumene in crystals weighing one to two hundred pounds, cymatolite as a result of the decomposition of spodumene crystals, sometimes nine inches in width, apatite, microlite (sp. gr. = 6), columbite (sp. gr. = 5·6), apatite, garnet, tourmaline and staurolite.

The manganesian phosphates and related minerals occur in nests imbedded in the albite. A single deposit yielded almost all the material obtained, it being probable that what came out as the result of our work was a part of the same body of minerals which Mr. Fillow had blasted into two years before. A second deposit will be mentioned later as having furnished the lithiophilite.

The minerals which form the mass of the first mentioned bed are:—Eosphorite, dickinsonite, triploidite and rhodochrosite. Of these, the first three are new and are described at length in this paper. These four minerals, together with quartz, occur associated in the most intimate manner possible, it being not at all unusual to find all of them in a single hand specimen. This is especially true of the three new minerals: the eosphorite is often found in crystals entirely imbedded in the dickinsonite, and again the finely disseminated plates of dickinsonite give a green color to much of the massive eosphorite. Quartz is also contained in much of the massive eosphorite, thus giving it a very anomalous appearance; it also forms the mass in which the triploidite crystals are imbedded—both these points are spoken of more particularly later. Quartz is also often associated with the rhodochrosite, that mineral being disseminated in crystalline grains through the

quartz, in which occasional brilliant cubes of pyrite are also imbedded.

In addition to the above minerals, as original constituents of the same deposit, are amblygonite (hebronite), and a phosphate of manganese isomorphous with scorodite which we shall describe under the name reddingite. As secondary products we have apatite and quartz coating together crystals of eosphorite, vivianite in thin layers and crystals, besides other species, which as yet, owing to lack of sufficient material for examination, we have been unable to determine.

Furthermore, there are a variety of alteration products: each one of the manganesian phosphates yields on alteration a black or purple phosphate of manganese and iron sesquioxides, and the rhodochrosite gives a pseudomorph of hydrated oxides.

The second smaller nest discovered consisted almost exclusively of lithiophilite. Of the previously mentioned minerals rhodochrosite is the only one we have observed with it, and that occurs very sparingly. In addition, however, a peculiar green manganiferous apatite, spodumene and cymatolite are intimately associated with the lithiophilite, besides the black phosphate produced from its oxidation, and occasional crystals of uraninite and both green and yellow hydrated phosphates of uranium.

From the large amount of black oxidized material, rich in lithia, found with the first deposit it is probable that lithiophilite, or some other similar mineral of the triphylite group, formed one of the original constituents of that mass. In fact it was the discovery of lithia in the black product of decomposition, and its absence in eosphorite, triploidite and dickinsonite, which led us to make further search for the source of this alkali. Fortunately, in the deepest part of our explorations in the vein we struck a small nest which afforded us the fresh unaltered mineral.

We wish here to express our great obligations to Messrs. Samuel L. Penfield and Horace L. Wells of the Sheffield Laboratory, for the excellent analyses which their enthusiastic devotion to the work has enabled us to present in this paper. The carrying through of these analyses has involved in many cases more than usual difficulty, and we appreciate fully to what an extent the value of this article is dependent upon the skill and patient care with which these difficulties have been overcome.

1. Eosphorite.

General physical characters.—Eosphorite occurs in prismatic crystals, sometimes of considerable size, which belong to the *orthorhombic system.* They show a nearly perfect macrodiagonal cleavage. It also and more commonly occurs massive, some specimens showing the cleavage finely, but graduating into others which are closely compact. The hardness is 5. For the

specific gravity, three perfectly pure rose-colored specimens gave 3·124, 3·134 and 3·145; mean 3·134. The luster of crystallized specimens is vitreous to sub-resinous, upon cleavage surfaces exceedingly brilliant; of the massive mineral often greasy. The color of the crystals is pink, some having the bright shade common in rose-quartz, while others are paler and have a yellow to gray hue; the smallest crystals are nearly colorless. The massive compact mineral is pale pink, also grayish-, bluish-, and yellowish-white, and white. Some varieties closely resemble in color and luster green elæolite; the green color, however, is shown by the examination of thin sections under the microscope to be due to finely-disseminated scales of dickinsonite. Some varieties again are rendered impure by the presence of quartz through the mass, and they then have a whitish color and granular texture; this subject is expanded in a later paragraph.

The mineral is transparent to translucent. The streak is nearly white, and the fracture uneven to subconchoidal.

Description of crystals.—Specimens of crystallized eosphorite are rare. The most of those obtained seem to have come from a single cavity, the crystals standing free, and projecting to some length. Again they are found completely imbedded, as, for in-

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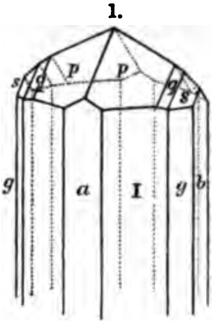

Eosphorite.

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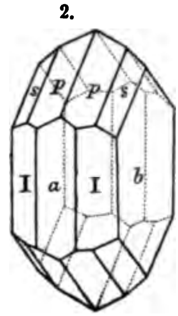

Childrenite, Hebron, Me.

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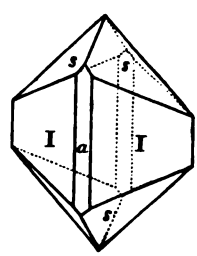


Childrenite, Tavistock.

stance, in dickinsonite. These crystals are in general small; but occasionally imperfect crystals of a considerable size are met with, one of these exposes a width of about an inch, and is two inches long; in another, a single plane has a width of nearly two inches. The planes are seldom well polished, and only in rare cases are exact measurements obtainable. This is due in part to the fact that the surfaces of the crystals are often coated with drusy quartz, and again with minute crystals of apatite, and also because the prismatic planes almost always, and the pyramidal planes very commonly, are finely striated. This striation of the prismatic planes is a marked characteristic and gives rise to rounded barrel-shaped crystals analogous to those observed of tourmaline and many other species.

The crystals are invariably prismatic in habit, and show but one terminated extremity; in this respect they differ from the ordinary childrenite of Tavistock, to which it will be shown they are closely related. The general form is shown in fig. 1.

The crystallographic measurements and also the optical examination prove that the crystals belong to the ORTHORHOMBIC SYSTEM.

The fundamental angles were obtained from measurements on a small crystal whose pyramidal planes gave excellent reflections. The mean of a considerable number of readings, whose extremes differed by only 1½′, was taken in each case. A goniometer provided with two telescopes was always employed. These angles* are as follows:—

$p \wedge p'$ or $111 \wedge 1\bar{1}1 = 46° \; 27' \; 45''$
$p \wedge p'$ or $111 \wedge \bar{1}11 = 61° \; 1' \; 54''$

From these the following axial ratio is obtained:—

c (vert.)	$\bar{b}$	$\breve{a}$
0·66299	1·28732	1·00000

The observed planes are as follows:

a	$i\text{-}\bar{\imath}$	100†	*p*	1	111
b	$i\text{-}\breve{\imath}$	010	*q*	$\frac{3}{2}\text{-}\breve{\frac{3}{2}}$	232
l	*I*	110	*s*	$2\text{-}\breve{2}$	121
g	$i\text{-}\breve{2}$	120			

The following is a list of the most important angles both calculated and measured, so far as the last have any value. The angles obtained from the prismatic planes in general, and conspicuously the macropinacoid *a* (100) were in most cases entirely unreliable.

			Calculated.	Measured.
$I \wedge I$	$110 \wedge 1\bar{1}0$	=	75° 41′	75° 36′
$g \wedge g$	$120 \wedge 1\bar{2}0$	=	114° 28′	
$a \wedge I$	$100 \wedge 110$	=	37° 50′	
$a \wedge g$	$100 \wedge 120$	=	57° 14′	
$b \wedge I$	$010 \wedge 110$	=	52° 10′	52° 12′
$b \wedge g$	$010 \wedge 120$	=	32° 46′	
$a \wedge p$	$100 \wedge 111$	=	59° 29′	
$a \wedge q$	$100 \wedge 232$	=	62° 19′	
$a \wedge s$	$100 \wedge 121$	=	65° 13′	
$b \wedge p$	$010 \wedge 111$	=	66° 46′	
$b \wedge q$	$010 \wedge 232$	=	57° 13′	

* The supplement angles, that is, the angles between the normals of the planes, are in all cases given.

† In making the shorter lateral axis *a*, and giving the symbol 100 to the macropinacoid, and 010 to the brachypinacoid, we follow Groth's Zeitschrift für Krystallographie. With Miller (whose method is adopted in Dana's Text-Book of Mineralogy) the reverse is true.

			Calculated.	Measured.
$b \wedge s$	$010 \wedge 121$	=	49° 21′	
$I \wedge p$	$110 \wedge 111$	=	49° 59′	49° 55′
$g \wedge s$	$120 \wedge 121$	=	39° 13′	
$p \wedge p'$	$111 \wedge 1\bar{1}1$	=	*46° 28′	46° 28′
$q \wedge q'$	$232 \wedge 2\bar{3}2$	=	65° 33′	
$s \wedge s'$	$121 \wedge 1\bar{2}1$	=	81° 18′	
$p \wedge p''$	$111 \wedge \bar{1}11$	=	*61° 2′	61° 2′
$q \wedge q''$	$232 \wedge \bar{2}32$	=	55° 22′	
$s \wedge s''$	$121 \wedge \bar{1}21$	=	49° 34′	49° 39′
$p \wedge p'''$	$111 \wedge \bar{1}\bar{1}1$	=	80° 2′	80° 0′
$q \wedge q'''$	$232 \wedge \bar{2}\bar{3}2$	=	91° 1′	
$s \wedge s'''$	$121 \wedge \bar{1}\bar{2}1$	=	101° 33′	
$p \wedge s$	$111 \wedge 121$	=	17° 25′	17° 18′

Eosphorite is in crystalline form closely homœomorphous with childrenite. Fig. 2 represents the common form of the childrenite from Hebron, Maine,* as we have found from an examination of the specimens in New Haven. The crystals are sometimes terminated at both extremities as here represented. It is placed in such a position as to correspond with the eosphorite, the pyramid *s* being identical in the two, as are also the prisms. Fig. 3 shows a common form of the Tavistock crystals; other crystals have the plane *b* present and resemble fig. 2 more closely in habit. The angles given below show the close relation in form between childrenite and eosphorite.

	Eosphorite.	Childrenite. Tavistock (Cooke.)	Childrenite. Hebron (Cooke.)	Childrenite. Tavistock (Miller.)
$I \wedge I$	75° 41′	75° 24′	74° 20′	75° 46′
$s \wedge s'$	81° 18′	81° 20′	80° 38′	82° 8′
$s \wedge s''$	49° 34′	49° 50′	50° 36′	49° 56′
$s \wedge s'''$	101° 33′	101° 43′	101° 36′	102° 41′

In order to bring the crystals of childrenite into this position the clinodome ($2\text{-}\breve{i}$, or *n* of Miller) is made the unit prism.

Optical properties.—A careful examination in the stauroscope proved that the three axes of elasticity coincide with the crystalline axes, showing that the crystals are really orthorhombic. The optic axes lie in the macrodiagonal section, or plane of cleavage, the acute bisectrix (first mean-line) being normal to the brachypinacoid, and the obtuse bisectrix consequently to the basal plane. The axial angle could not be obtained with very great accuracy, owing to the fact that the best sections left much to be desired in the way of clearness. The measurements gave:—

$$2E = 54° \; 30' \quad \text{red rays.}$$
$$= 60° \; 30 \quad \text{blue rays.}$$

The dispersion of the axes is strong, $v > \rho$; the character of the double-refraction is negative.

* This Journ., II, xxxvi, 257, 258.

An examination of a parallelopided cut with its edges parallel to the three axes of elasticity (crystalline axes) showed a very distinct trichroism. The axial colors are as follows:

For vibrations parallel to $\mathfrak{a}$ (that is $\bar{b}$) yellowish.
$\mathfrak{b}$ (that is $\breve{a}$) deep pink.
$\mathfrak{c}$ (that is c (vert.)) faint pink to nearly colorless.

Chemical composition.—The finest of the pink crystals were used for the chemical examination of eosphorite, which was made by Mr. Samuel L. Penfield, assistant in the Sheffield Laboratory. A qualitative analysis having shown the presence of alumina, protoxides of iron and manganese, lime, soda, phosphoric acid and water, the following method was employed in the quantitative separation of the constituents. The total phosphoric acid was determined by means of ammonium molybdate. To determine the bases, one gram of the mineral was fused with sodium carbonate, the fused mass soaked out in water and the solution filtered from the residue of oxides of iron and manganese. Most of the alumina went into solution with the sodium phosphate. The residue of oxides of iron and manganese was dissolved in hydrochloric acid and the iron separated from the manganese by means of a basic acetate precipitation. To insure the complete separation of the alumina from the iron, the precipitate of basic acetate of iron was boiled with sodium hydroxide, the solution filtered off and added to the solution from the fusion, the oxide of iron was then dissolved in hydrochloric acid, the iron precipitated with ammonia and weighed as iron sesquioxide. The iron was then dissolved in hydrochloric acid, evaporated with nitric acid and ammonium molybdate added to precipitate any phosphoric acid which might not have been separated by the sodium carbonate fusion. In this case there was a complete separation. From the filtrate from the basic acetate precipitation, manganese was precipitated by means of bromine, the precipitate dissolved in hydrochloric acid, the manganese again precipitated as ammonio-manganese phosphate and weighed as pyrophosphate. From the filtrates from the precipitation by bromine, lime was thrown down as oxalate. The solutions containing the alumina were acidified with hydrochloric acid, boiled to expel carbonic acid, and aluminum phosphate precipitated by means of ammonia; the precipitate was filtered, washed, dissolved and again precipitated and weighed as aluminum phosphate. As this precipitate is not constant in composition, after weighing, it was dissolved in nitric acid and the phosphoric acid separated by means of ammonium molybdate. The phosphoric acid was determined and deducted from the weight of the aluminum phosphate.

The sodium was determined by precipitating the bases from

an acid solution by means of ammonium carbonate, evaporating the filtrate to dryness, igniting to drive off ammonium salts. The residue was taken up in water, barium hydroxide added to precipitate any phosphoric acid or manganese which might have remained in solution, the excess of barium separated and the sodium weighed as sodium chloride. Care was taken to carry on the evaporations in platinum and avoid contact with glass as much as possible. Water was determined by igniting in a Bohemian glass tube in a gas furnace, the water being collected in a chloride of calcium tube.

Two analyses gave:

	I.	II.	Mean.	Relative number of atoms calculated from the mean.			
P_2O_5	31·10	30·99	31·05		·219	1·	1·
$\text{Al}O_3$	21·99	22·40	22·19		·216	·99	1·
FeO	7·42	7·39	7·40	·103			
MnO	23·47	23·56	23·51	·331	·449	2·05	2·
CaO	·54	·54	·54	·010			
Na_2O	·33	·33	·33	·005			
H_2O	15·66	15·54	15·60		·866	3·95	4·
	100·51	100·75	100·62				

The ratio $P_2O_5 : \text{Al}O_3 : RO : H_2O = 1 : 1 : 2 : 4$ corresponds to the empirical formula $R_2\text{Al}P_2O_{10}$, $4H_2O$, which may be written $\text{Al}P_2O_8 + 2H_2RO_2 + 2aq$. The analogy in the composition of eosphorite to that of childrenite suggests, however, that the better way of writing the formula is:

$$\left\{\begin{matrix} R_3P_2O_8 \\ \text{Al}P_2O_8 \end{matrix}\right. + \left\{\begin{matrix} H_2RO_2 \\ H_6\text{Al}O_6 \end{matrix}\right. + 4aq.$$

In the formula R corresponds to Mn and Fe with small quantities of Ca and Na_2; the ratio for $Mn : Fe + Ca + Na_2 = 3 : 1$, and for $Mn : Fe = 10 : 3$; for the last ratio the above formula requires:—

	Eosphorite. Calculated from the formula.	Childrenite, analyzed by Rammelsberg.	Childrenite, analyzed by Church.
P_2O_5	30·93	28·92	30·65
$\text{Al}O_3$	22·35	14·44	15·85
FeO	7·24	30·68	FeO_3 3·51 FeO2 3·45
MnO	23·80	9·07	7·74
MgO		0·14	1·03
H_2O	15·68	16·98	17·10
	100·00 G.=3·134	100·23 G.=3·247	99·33 G.=3·22

The identity between the crystalline form of eosphorite and that of childrenite has been pointed out in a preceding paragraph, and the analogy between them in chemical composition, and at the same time the wide difference, will be seen from the above. The ratios obtained from the analyses of Rammelsberg and Church for the childrenite from Tavistock and that of eosphorite are as follows:—

		P_2O_5	:	$\bar{R}O_3$	:	RO	:	H_2O	
Childrenite	Rg.	3	:	2	:	8	:	15	
	Ch.	4	:	3	:	9	:	18	
Eosphorite		1	:	1	:	2	:	4	and

		P_2O_5	:	$\bar{R}O_3+RO$	:	H_2O
Childrenite	Rg.	1	:	$3\frac{1}{2}$	:	5
	Ch.	1	:	3	:	$4\frac{1}{2}$
Eosphorite		1	:	3	:	4

It can hardly be doubted from the above relations and the other facts given that the two species are in fact isomorphous, although the uncertainty that hangs over the composition of childrenite makes it useless to compare the formulas. It is quite possible that, when the composition of childrenite shall be definitely settled, it will be found to be analogous to that given for eosphorite. It cannot be questioned, however, that the two species though closely isomorphous, are at the same time perfectly distinct: the physical characters, the habit of crystals, and method of occurrence speak emphatically for this. Chemically, too, they are not to be confounded, although they may be similar compounds; eosphorite is essentially a phosphate of aluminum and *manganese*, and childrenite of aluminum and *iron*.

Pyrognostics.—In the closed tube eosphorite decrepitates, whitens, gives off abundance of neutral water, and the residue turns first black, then gray, and finally liver-brown with a metallic luster, and becomes magnetic. B.B. in the forceps it cracks open, sprouts and whitens, colors the flame pale-green, and fuses at about four to a black magnetic mass. It dissolves completely in the fluxes, giving iron and manganese reactions. It is soluble in nitric and hydrochloric acids.

In order to make certain that our conclusions that the compact mineral with greasy luster and resembling elæolite was but a variety of eosphorite, we selected a grayish white and apparently homogeneous specimen, which was analyzed by Mr. Horace L. Wells, with the following results:

P_2O_5	26·93
$\bar{A}lO_3$	18·70
FeO	5·86
MnO	19·21
CaO	2·58
H_2O	12·92
Residue	14·41
Alkalies and fluorine	*traces*
	100·61

An examination of the residue insoluble in acids proved it to consist chiefly of quartz. The 0·144 gram of insoluble residue gave 0·131 silica (92·8 per cent), and contained besides traces of iron, alumina and perhaps other bases. The examination

of a thin section of this variety of eosphorite showed the quartz scattered as grains through the mass.

Deducting the residue from the analysis and calculating again to 100·61, we have

		Atoms.		
P_2O_5	31·43	·221	·221	1
AlO_3	21·83	·212	·212	1
MnO	22·43	·316		
FeO	6·84	·096	·466	2
CaO	3·01	·054		
H_2O	15·07	·837	·837	4

This is very nearly the composition of eosphorite as analyzed by Penfield. The excess of lime is in part due to the presence of apatite which is found associated with much of the eosphorite. The compact mineral is simply eosphorite intimately mixed with quartz and other species found at the locality. The greener colored varieties contain dickinsonite and are somewhat more fusible than pure eosphorite, while the lighter colored varieties such as analyzed are more difficultly fusible. The density of these varieties varied from 2·92—3·08.

The name eosphorite is from the Greek ἠωσφόρος (a synonym of φωσφόρος, whence the name phosphorus), which means *dawn-bearing*, in allusion to the characteristic pink color of the crystallized mineral.

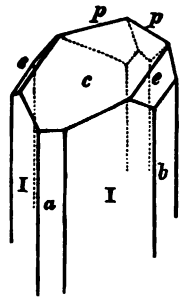
2. Triploidite.

Physical characters.—Triploidite occurs in crystalline aggregates which are distinctly parallel-fibrous to columnar in some cases, and in others divergent; and again confusedly fibrous to nearly compact massive. Occasionally individual prismatic crystals are distinct, being separated from one another by the transparent quartz in which they are imbedded and from which they become detached when the mass is broken into small fragments. The isolated crystals have sometimes a length of an inch or more, but it is not possible to detach them except in very small pieces. The conditions are obviously extremely unfavorable to the formation of terminated crystals, but a careful and long-continued search upon a large amount of material was at last rewarded by the discovery of a few more or less perfect specimens. In rare instances the crystals have been observed standing free in small cavities in the massive mineral. The crystals have perfect orthodiagonal cleavage.

The hardness of triploidite is 4·5–5, and the specific gravity 3·697. The luster is vitreous to greasy-adamantine. The color is yellowish to reddish-brown, in the distinct crystals also topaz- to wine-yellow, and occasionally hyacinth-red. The streak is nearly white. Transparent to translucent. The fracture is subconchoidal.

Crystalline form.—Of the few terminated crystals obtained, three only were suitable for measurement and only one of these had the terminations complete. These were extremely small, but the planes were of so high a luster that they gave good reflections, but little inferior to those obtained from the best eosphorite crystals. The planes in the prismatic zone are in the larger crystals so much striated as to admit of no satisfactory measurements. In the crystals selected for careful measurement the only planes in this zone which could not be used at all were the clinopinacoids, for the others the reflections were reasonably good. The crystals show occasionally false planes, bearing no relation to the axes of the crystal, and which are evidently impressions of portions of adjoining crystals.

4.



The crystals belong to the MONOCLINIC SYSTEM and their habit is shown in figure 4. The axial ratio was obtained from the following fundamental angles:—

$c \wedge e$	=	$001 \wedge 011$	=	54° 48′
$a \wedge I$	=	$100 \wedge 110$	=	60° 27′
$a \wedge c$	=	$100 \wedge 001$	=	71° 46′

These angles are good, though a little less so than those given for eosphorite—the probable error, however, does not exceed ±1′. The axial ratio is:

c (vert.)	b	$\grave{a}$
0·80367	0·53846	1·00000.

The observed planes are:

c,	O,	001.	I,	I,	110.
b,	i-$\grave{i}$,	010.	e,	1-$\grave{i}$,	011.
a,	i-$\bar{i}$,	100.	p,	2-2,	$2\bar{1}1$.

The following are the principal angles, both calculated from the above data, and as measured on the same crystal (1) and on the two others (2 and 3):

		Calculated.	Measured. (1)	(2) (3)
$I \wedge I'$,	$110 \wedge 1\bar{1}0$,	=120° 54′		120° 52′ (3) 120° 54′
$I \wedge I'$,	$110 \wedge \bar{1}10$,	= 59° 6′		
$a \wedge c$,	$100 \wedge 001$,	= 71° 56′	*71° 56′	71° 55′ (3)
$a \wedge e$,	$100 \wedge 011$,	= 79° 37′	79° 36′	
$a \wedge I$,	$100 \wedge 110$,	= 60° 27′	*60° 27′ 60° 26′	
$a \wedge p$,	$\bar{1}00 \wedge \bar{2}11$,	= 52° 49′	52° 45′	
$b \wedge e$,	$010 \wedge 011$,	= 35° 12′		
$b \wedge m$,	$010 \wedge 110$,	= 29° 33′		
$b \wedge p$,	$010 \wedge \bar{2}11$,	= 48° 33′		
$c \wedge e$,	$001 \wedge 011$,	= 54° 48′	*54° 48′	54° 49′ (2)

		Calculated.	Measured. (1)	(2)	(3)
$c \wedge I$,	$001 \wedge 110$,	= 81° 7′	81° 6′		
$c \wedge I'$,	$001 \wedge \bar{1}10$,	= 98° 53′	98° 52′		
$c \wedge p$,	$001 \wedge \bar{2}11$,	= 76° 35′	76° 20′ approx.		
$I \wedge p$,	$\bar{1}10 \wedge \bar{2}11$,	= 29° 6′			
$e \wedge I$,	$011 \wedge 110$,	= 36° 53′	36° 50′	36° 57′ (2)	
$e \wedge I'$,	$011 \wedge \bar{1}10$,	= 51° 33′	51° 24′		
$e \wedge p$,	$011 \wedge \bar{2}11$,	= 47° 34′	48° approx.		
$e \wedge e'$,	$011 \wedge 0\bar{1}1$,	=109° 36′			
$p \wedge p'$,	$\bar{2}11 \wedge \bar{2}\bar{1}1$,	= 82° 53′			

A comparison of the above angles with those given by Brooke and Miller for wagnerite shows that the two species are homœomorphous.

Thus in the three diametral zones, we have :—

	Triploidite.	Wagnerite (Miller).
$I \wedge I'$,	$110 \wedge 1\bar{1}0$,=120° 54′	$g \wedge g$=122° 25′
$c \wedge a$,	$001 \wedge 100$,= 71° 46′	$c \wedge a$= 71° 53′
$e \wedge e'$,	$011 \wedge 0\bar{1}1$,=109° 36′	$e \wedge e'$=110° 6′

As the crystal of wagnerite is placed by Miller, the planes g, a, c and e have the symbols ($1\bar{2}0$), ($\bar{1}00$), (001), (021) respectively. In the figure given by Miller the prism g $\bar{1}20$ (= I, ($1\bar{1}0$) triploidite) has the greatest development; it was made the unit prism by Naumann.

Optical properties.—The only point that could be established in regard to the optical character of triploidite was the position of the axes of elasticity. The crystal used for measurement had the clinopinacoid so far developed that it could be examined directly in a Rosenbusch microscope. It was found that of the two axes which lie in the plane of symmetry, one very nearly coincides with the vertical axis, being inclined behind (see fig. 4) 3°–4°, and the other consequently is almost normal to the orthopinacoid. The position of the optic axes could not be fixed. The crystals show no perceptible absorption phenomena.

Chemical composition.—Triploidite was analyzed by Mr. Penfield. This hydrous phosphate was found to contain iron and manganese, both being in the lowest state of oxidation, with a small amount of lime; it is entirely free from fluorine. The method of analysis was substantially the same as that of eosphorite, (described on page 39). There being no alumina in the mineral, the phosphoric acid was determined directly from the solution of the fusion. The fusion did not effect a complete separation of the phosphoric acid from the iron and manganese, as it was retained by the small amount of lime present. It was weighed with the iron, and afterwards was separated from the iron by means of ammonium molyb-

date, determined, deducted from the weight of the latter and added to the phosphoric acid determination. The results of two analyses are:

	I.	II.	Mean.	Relative number of atoms calculated from the mean.			
P_2O_5	32·14	32·08	32·11		·226	1·	1·
FeO	15·07	14·69	14·88	·207			
MnO	48·35	48·55	48·45	·682	895	3·96	4·
CaO	·36	·29	·33	·006			
H_2O	4·01	4·15	4·08		·226	1·00	1·
	99·93	99·76	99·85				

The ratio $P_2O_5 : RO : H_2O = 1:4:1$ corresponds to the formula $R_4P_2O_9+H_2O$, or $R_3P_2O_8+H_2RO_2$, where $R=Mn:Fe=3:1$. This formula requires:

P_2O_5	31·91
FeO	16·18
MnO	47·86
H_2O	4·05
	100·00

Among the other phosphates and arsenates the following seem to be closely related to triploidite in composition:

Libethenite	$Cu_3P_2O_8+H_2CuO_2$	Orthorhombic.
Olivenite	$Cu_3(P_2,As_2)O_8+H_2CuO_2$	Orthorhombic.
Lazulite	$\text{Æ}lP_2O_8+H_6\text{Æ}lO_6$	Monoclinic.

None of these species has any relation to triploidite in crystalline form. On the other hand the similarity between the angles of wagnerite and triploidite has already been shown; moreover, the composition of triplite is analogous to that of wagnerite and for these reasons a relation between triplite and triploidite immediately suggests itself. The composition of these minerals is:

Wagnerite	$Mg_3P_2O_8+MgF_2$
Triplite	$(Fe, Mn)_3P_2O_8+(Fe, Mn)F_2$
Triploidite	$(Mn, Fe)_3P_2O_8+(Mn, Fe)(OH)_2$

It should be stated that the perfect transparency and brilliant luster of the crystals analyzed prove beyond all question that the absence of fluorine and the presence of water (determined directly) are not due to any alteration. The fact that all the bases are in the lower state of oxidation would be confirmatory evidence were it needed. The conclusion to which we are led is this—that in the compound triploidite the radical hydroxyl (OH) plays the same part as the element fluorine, the molecule $R(OH)_2$ taking the place of the RF_2.

Pyrognostics.—In the closed tube triploidite gives neutral water, turns black and becomes magnetic. Fuses quietly in the naked lamp flame and B. B. in the forceps, colors the flame green. Dissolves in the fluxes, giving reactions for manganese and iron. Soluble in acids.

An analysis of another specimen of triploidite gave P_2O_5 32·24, FeO 18·65, MnO 42·96, CaO not determined, H_2O 4·09, quartz 1·09. The lime was accidentally lost but calculating from the amount of phosphoric acid retained by the iron it amounted to 0·90 per cent. The analysis is interesting as showing that the iron and manganese vary in different specimens, the darker colored varieties containing the most iron.

The name *triploidite* given to this species, from *triplite*, and *εἶδος form*, indicates its resemblance to triplite in physical characters, and its relation in chemical composition.

(To be continued.)

ART. V.—*On Dinitroparadibrombenzols and their Derivatives;* by Dr. P. TOWNSEND AUSTEN, F.C.S., Assistant Prof. of Chemistry in Rutgers College. Third paper.*

IN my former papers, I have described the formation of three dinitroparadibrombenzols, and proved the α and β variations to be isomeric compounds. With regard to the third, I am still somewhat in doubt.

The peculiar formation of nitroparadibromaniline by treatment of alpha dinitroparadibrombenzol with ammonia, has led me to make experiments with other reagents, and I have been gratified at encountering some quite unexpected phenomena. These I shall mention in another paper.

Beta-dinitroparabromphenol.

By pouring a very concentrated alcoholic solution of potassa over the beta-dinitrodibrombenzol, the mass became scarlet-red, indicating the formation of a salt. Examination showed, however, that much of the substance was left unaffected. On heating, an action set in, and fine bubbles were formed. On diluting with alcohol and acidifying with hydrochloric acid, a dark brown flocculent mass was obtained, insoluble to any extent in alcohol. It was soluble in glacial acetic acid and acetic ether, separating in the form of an amorphous powder. As it was also soluble in a solution of sodium hydrate, and was precipitated therefrom by hydrochloric acid, I take it to be an azoxyphenol.

Various attempts to obtain a good yield of the phenol by direct treatment with potassa, or soda, in different amounts and solvents, did not meet with success, except on a small scale. Although in most cases, the phenol salt was formed, as could be discerned from the red color of the liquid, yet on application

* Compare this Journal, III, ix, 118, and xiii, 95.

of heat, the speedy browning of the liquid showed that a more vital action had taken place. The best results with this method were obtained by long boiling of the dinitrodibrombenzol with an aqueous solution of potassa. Owing, however, to the slight solubility of the nitro-compound in water, but a small amount of the phenol salt was formed.

I then endeavored to utilize a reaction which I described, some time ago,* as taking place between dinitromonobrombenzol and potassium nitrite, when the two substances are heated under pressure in presence of dilute alcohol. The formation of dinitrophenol takes place easily:

$$C_6H_3(NO_2)_2Br + 2KNO_2 = C_6H_3(NO_2)_2OK + KBr + N_2O_3(?)$$

The resulting oxide or oxides of nitrogen have here the beneficial effect of exerting an oxidizing action. The great objection to the use of an alkali in forming hydroxyl derivatives from nitro-halides, is the tendency it has to affect the nitro-groups converting them into azoxy-compounds. By the use of potassium nitrite all reducing action is avoided—in fact, prevented—by the presence of the nitrogen oxide. The oxides react also on the alcohol present, forming aldehyde.

Some of the β-dinitroparadibrombenzol was dissolved in dilute alcohol, and an equal weight of KNO_2 added. On standing, the KNO_2 extracts the water from the dilute alcohol, forming an aqueous layer on which the alcoholic solution rests. By standing, even without warming, the line of contact between these layers solidifies to a crust of red needles. On boiling, however, the action is soon complete, and every trace of the β-isomer is converted into the phenol. The reaction is precisely analogous to the former:

$$C_6H_2(NO_2)_2Br_2 + 2KONO = C_6H_2(NO_2)_2BrOK + KBr + N_2O_3(?)$$

Some of the pure α was then treated in a similar manner, but did not suffer the slightest change. Some samples of KNO_2 gave a slight coloration, but this was owing to the presence of free potassium hydrate. They gave no reaction after the potassium nitrite had been moistened with a few drops of dilute nitric acid.

The oil that I take to be a gamma-isomer, also remained unaffected.

This method enables me to overcome several hitherto almost insurmountable obstacles. The separation and purification of the beta from the alpha by crystallization is extremely difficult, and from the gamma almost impossible. By direct treatment with KNO_2, of the mass obtained by nitrition of the dibrombenzol however, all the beta isomer can be extracted in the form of phenol salt, leaving only the alpha, a solid substance

* This Journal, August, 1876.

fusing at 159°, and the gamma, an oil, which I hope will prove easy of separation.

It also forms an excellent test of the purity of the alpha-compound, since the color of the potassium beta-phenylate is so vivid, that if the alpha contains the slightest trace of the beta, it is shown by the formation of a red tint on boiling it with dilute alcohol and potassium nitrite. By treating the beta-compound in the same manner, evaporating to dryness and extracting with hot carbon disulphide, an admixture of the alpha and gamma modifications is easily revealed. In this manner, I have succeeded in proving that several specimens of what I thought to be pure alpha and beta, were not absolutely free from isomers, although the fusing points had long since ceased to show any appreciable variation.

Finally this method promises a means of obtaining phenols by substitution of the halide in those nitro-halides which on treatment with an alkali suffer substitution of the nitro-group.* For if a reaction takes place it is only the halide which can be affected.

Preparation.—150 grams of the raw product, obtained by nitrition of the paradibrombenzol, were treated in a flask with boiling absolute alcohol until all was in solution. The boiling liquid was diluted with hot water until the substance began to permanently separate. Alcohol was then added until solution had taken place, on which water was again added, the liquid being kept boiling all the time. In this manner, by successively adding water and alcohol, the volume of the liquid was brought up to about 1½ liters. The object of this excessive dilution was to prevent the separation of the liquid into two layers from the removal of the water by the KNO_2. The flask was taken off the sand bath, and 100 grms. of KNO_2 carefully added. It was then replaced, and the liquid allowed to boil violently.

The formation of the phenol salt took place quickly. In about half an hour, during which water was occasionally added to replace the loss by evaporation, the reaction was completed. The contents of the flask were poured into a tall beaker holding about 1½ liters of cold water, stirred, allowed to settle, and washed several times by decantation to remove the potassium bromide and unchanged potassium nitrite. The mass was brought on a filter and allowed to drain, after which it was placed in a dish and heated in a water bath till all moisture was driven off. By repeated warming with carbon disulphide, all traces of the unchanged isomers were easily removed. The red salt was then purified by crystallization from dilute alcohol, dissolved in boiling water and carefully decolorized with di-

* As for instance the dinitro-chlorbenzol of Laubenheimer, Ber. d. d. chem. Ges., viii, 1929; ix, 768.

lute* hydrochloric acid (1 : 10), filtered, washed and purified by crystallization from dilute alcohol.†

Analysis.—A combustion gave:

0·2852 grms. of substance yielded 0·2870 grms. of CO_2 and 0·0422 grms. of H_2O.

$$\text{The formula } C_6H_2 \begin{cases} NO_2 \\ NO_2 \\ Br \\ OH \end{cases} = C_6H_3N_2O_5Br.$$

Calculated.	Found.
C=27·38	27·44
H= 1·13	1·64

Properties.—This compound is identical with the dinitrobromphenol obtained by Körner‡ from nitrition of bromphenol. It forms when crystallized from water or alcohol, long, flat, very thin and strongly glittering needles, fusing at 71°. Körner found 78°. On careful heating it volatilizes unchanged. Exposed to the air it soon turns reddish, undoubtedly, as Körner suggested, from the presence of ammonia. Heated under water, it fuses to a yellow oil. It has strong tinctorial powers, dying the skin yellow. In all these properties my observations agree entirely with those of Körner. By heating with concentrated sulphuric acid, decomposition sets in, and a gas is liberated which smells like nitrous acid, while a (sulpho?) acid giving a barium-salt soluble in water, is obtained. When heated on a platinum foil, it burns brightly with a luminous yellow, smoky flame. Thrown on a red-hot platinum foil it puffs.

On heating the phenol with fuming nitric acid a violent action took place. The resulting liquid on evaporation furnish an abundant quantity of *picric acid.*

There are already several instances known where picric acid is formed by the substitution of a halide by the nitro-group. A directly analogous case is quoted by Post‡ who mentions that picric acid is formed by nitrition of the phenol isomeric to this (dinitrobromphenol fusing at 117°).§ This proves conclusively then, that, when a halide is expelled by direct treatment with nitric acid, we are not in a condition to assume that the entering nitro-group takes the same relative position as the antecedent halide; for, as in the case above shown, both the dinitrobromphenols give picric acid on nitrition.

* In many cases the addition of concentrated hydrochloric acid to a hot, concentrated solution of a nitro-phenol salt, will entirely decompose the phenol. If I am not mistaken, this fact has already been noticed, but I cannot recall the reference.

† This compound is also formed when β-dinitroparabromaniline is heated with a solution of potassium hydrate.

‡ Ber. d. d. Chem. Ges., vii, 334.

§ Armstrong, Ber. d. d. Chem. Ges., vi, 649.

It is not a little peculiar that nitric acid should drive the bromine atom out of dinitrobromphenol, forming picric acid; for picric acid when treated with bromine, yields* dinitrobromphenol.

Solubility.—Difficultly soluble in boiling water. Apparently less easily soluble in boiling dilute hydrochloric and nitric acids. Easily soluble in boiling dilute sulphuric acid. In hot alcohol and acetic acid (glacial) very easily soluble. In carbon disulphide, less easily. In hot aniline it is very easily dissolved, giving a red solution.

Silver Beta-dinitroparabromphenylate.

Preparation.—The salt was made by mixing aqueous solutions of silver nitrate and ammonium dinitrobromphenylate. It is difficultly soluble in boiling water, but much more easily in alcohol.

Analysis.—

$$C_6H_2\begin{cases} NO_2 \\ NO_2 \\ Br \\ OAg \end{cases} = C_6H_2N_2O_5AgBr.$$

0·4903 grams of substance yielded 0·1884 grams of AgCl.

Calculated.	Found.
Ag=29·19	28·90

Properties.—Splendid glittering red needles, having a brilliant green reflex. When dry the salt puffs on heating. If thrown on a hot surface, it explodes.

Potassium Beta-dinitroparabromphenylate.

I have already described the formation of this salt. It is somewhat difficultly soluble in boiling water. It forms long glittering and red needles, having a greenish reflex. This is the only salt that Körner prepared. He considers the play of colors to be like that of murexide.

Barium Beta-dinitroparabromphenylate.

Preparation.—Barium carbonate was boiled with a dilute alcoholic solution of the phenol until all carbonic anhydride was expelled. The residue was extracted with boiling water, filtered and allowed to crystallize.

Analysis.—

$$(C_6H_2(NO_2)_2BrO)_2Ba = C_{12}H_4K_4O_{12}Br_2Ba$$

0·3824 grams of substance gave 0·1331 grams of $BaSO_4$.

Calculated.	Found.
Ba=20·72	20·46

Properties.—Saffron-yellow needles. Moderately soluble in hot water or alcohol. When heated in a mattrass, it explodes, covering the sides with carbon.

* Armstrong, Ber. d. d. Chem. Ges., vi, 650.

Ammonium Beta-dinitroparabromphenylate.

Preparation.—By action of ammonia on an alcoholic solution of the phenol.

Analysis.—

$$C_6H_2(NO_2)_2BrONH_4 = C_6H_6N_3O_5Br$$

0·52 grams of substance gave 0·4 grams of $PtCl_4$, 2AmCl.

Calculated.	Found.
$NH_4 = 6·52$	6·20

Properties.—Bright red silky needles. Soluble in boiling water and alcohol. When heated in a mattrass to 140°, it is volatile, forming a red sublimate which can be driven about by cautious heating. On higher heating it is dissociated into ammonia and phenol. A partial recombination takes place on cooling.

Copper Beta-dinitroparabromphenylate.

Preparation.—It was obtained by action of a slight excess of well-washed $CuCO_3$ on the phenol in boiling dilute alcoholic solution. The resulting mass was dissolved in glacial acetic acid. The salt was thereby decomposed, cupric acetate and free phenol being formed. On diluting the blue solution carefully with water, a point was reached where the color changed to brown. The solution was then allowed to stand. After a short time the substance began to separate in crystals.*

Properties.—The salt crystallizes in short, brown glittering needles. It is insoluble in water and alcohol. Moderately soluble in boiling acetic acid. The best way to obtain it in solution, is to dissolve it in glacial acetic acid, and dilute with water until the blue color changes to brown.

None of these salts contain water of crystallization and differ here from the salts of the isomeric dinitrobromphenol of Armstrong.

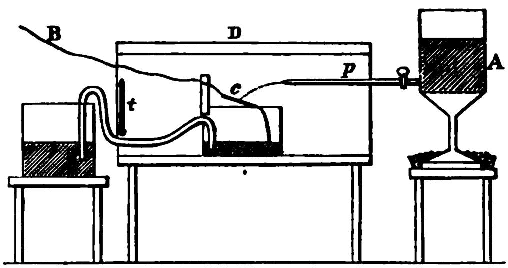
When I found that this phenol could be so easily obtained, I hoped that by action of phosphorous pentabromide, it could be converted back into β-dinitroparadibrombenzol. All attempts in this direction have as yet failed. The larger part of the phenol remains unchanged on treatment with the bromide, while some of it is entirely decomposed.

New Brunswick, N. J., April 1st, 1878.

* It would be interesting to determine exactly at what point of dilution the acetic acid becomes equal to the phenol in its attraction to the copper.

ART. VI.—*The effect of Temperature upon Atmospheric Electricity;* by HENRY GOLDMARK. (Contributions from the Physical Laboratory of Harvard College. No. 24.)

SIR WILLIAM THOMSON, by means of the different forms of electrometers, devised by himself, has investigated the electric potential of the atmosphere under varying conditions and in different localities. The effect of an increase of temperature upon the potential of the air he does not appear to have ascertained, and the following experiments were undertaken with a view of arriving at some conclusion upon this subject. From the nature of the case the measurements made were approximate, and the results reached qualitative rather than quantitative. To get the potential of the air at any point I used the water-dropping apparatus devised by Thomson. Its construction will be readily understood by reference to the sectional view given below.



It consists merely of a can of water A, insulated by standing upon a glass support, and discharging by the small pipe *p* through a fine nozzle. The insulation is made more perfect by drying the atmosphere around the insulating stem by means of small pieces of pumice stone, moistened with sulphuric acid and placed around its base.

The water breaking into drops from the nozzle assumes the potential of the air at the point and communicates it to the copper plate C, from which the insulated wire B leads to the electrometer. In order to investigate the effect of different temperatures upon the potential, it was necessary to have a limited volume of air upon which to experiment. To do this I enclosed the nozzle of the water-dropping tube and the copper plate in the interior of the cylindrical drum D. This drum was made of several layers of sheet iron, so arranged that the air, after being heated by three Bunsen burners below, would pass several times around the cylinder and so raise the temperature of the enclosed air, without otherwise affecting it. The water which dropped from the plate collected in the glass dish below from which it was drained out by a syphon, as fast as it fell.

To *measure* the potential I employed one of Thomson's quadrant electrometers, which was charged sometimes by a Holtz machine and sometimes by the Ruhmkorff coil. This instrument carries a small concave mirror which reflects a spot of light upon a scale of ground-glass placed at the distance of about a meter. In order to avoid any influence which the observer's body near the instrument or conducting wires might make, I observed the deflections upon this scale by means of a telescope from the opposite end of the room.

The method of procedure was as follows: The opposite quadrants of the electrometer were connected with two of the four binding screws of a peculiar key constructed for the instrument, while to the other two the wire coming from the measuring instrument and a wire leading to the earth were respectively attached. The potential of the air in the drum was then measured, the temperature being that of the air of the room. The result showed a very constant negative potential, varying but little in the successive days on which the experiment was made. The potential of the air of the room was also measured at the same time, and found to be the same as that of the enclosed air, thus proving that the drum had no effect upon the electric condition of its contents. The burners were then lighted, and the potential was, from time to time, measured after the temperature of the enclosed air, as observed by the thermometer t, had risen above that outside.

The change was by no means marked, but I did not on any occasion, notice any decrease of potential, but on the contrary a small but constant increase on raising the temperature. The following table gives some of the measurements made:

April 21.		April 24.		April 25.	
Temp. in Cent. deg.	Potential in scale div.	Temp. in Cent. deg.	Potential in scale div.	Temp. in Cent. deg.	Potential in scale div.
20½	15½	23	15	22	15½
30	19	50	20½	42	19½
60	20	67	23	74	20½
				88	22
				96	23

On extinguishing the burners and allowing the enclosed air to cool slowly, it retained the maximum potential it had reached on heating, even after it had regained its original low temperature.

As a result of my experiments I arrived at the following conclusions:

1st. That, even a very considerable change of temperature, does not have *any great* or *marked* effect upon the electric potential of the air.

2d. That however a rise in temperature does produce a *slight but constant* increase in the potential.

ART. VII.—*A method of recording Articulate Vibrations by means of Photography;* by E. W. BLAKE, Jr., Hazard Professor of Physics, Brown University.

THE extreme minuteness of the vibrations of the iron disc of the Bell telephone withdraws them from all ordinary methods of observation and measurement. A pointed wire fastened to the center of a ferrotype disc $2\frac{3}{4}$ inches in diameter, and moving on smoked glass, gave $\frac{1}{16}$ inches as the extreme amplitude of vibration under a powerful impulse of the voice, while sounds moderated to such a point as to be fairly articulate, were with difficulty detected by the movement which they communicated.

Animal membranes, possessing greater flexibility than the metal disc, seemed to promise better results, but the inertia of the attached wire, and the resistance offered by the smoked surface, become of importance, and throw doubt on the accuracy of the results obtained. Dr. Clarence J. Blake employs the human *membrana tympani* as a logograph,* and has obtained very beautiful and interesting tracings. I find by examination of some, which he kindly sent me, that the number of vibrations as recorded falls considerably below the ordinary pitch of the voice, being in some cases as low as 80 per second.

The logograph described by W. H. Barlow, F.R.S., in a paper read before the Royal Society,† serves to record the varying pressures of the expelled air taken as a whole. With a single exception the diagrams give no suggestion of the *musical* character of the sounds. The width of the line drawn by a camel's hair brush and the slow movement of the paper would mask the minute vibrations even if the apparatus were otherwise adapted to showing them.

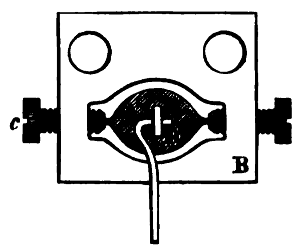
The opeioscope, invented by Professor A. E. Dolbear, consisting of a tense membrane, to the center of which a small mirror is attached, is well adapted to proving the existence of musical vibrations in human speech, but not to determining their character.

The phonograph of Mr. Edison records on tin-foil enough of the vocal elements to reproduce intelligible articulation. The minute indentations are therefore a record of great scientific value. In the hands of Mr. Fleeming Jenkin they promise to lead to valuable results‡ in the analysis of vocal sounds.

Dr. S. Th. Stein§ described in 1876 a method of photograph-

* Archives of Opthalmology and Otology, vol. v, No. 1, 1876.
† Reprinted in the Popular Science Review, London, July, 1874.
‡ Nature, May 9th, 1878. Article on Phonograph by Mr. J. Ellis.
§ Poggendorff's Annalen, Bd. clix, S. 142.

he vibrations of tuning forks, strings, &c., by attaching to
ı plates of blackened mica punctured with small holes. A
ı of sunlight passing through the hole strikes a sensitive
ı moving with uniform velocity, and leaves a permanent
'd of the combined motions. Dr. Stein considers his
ıod applicable to *vocal* sounds, but I cannot learn that he
ɔver attempted this application. My own experiments in
direction by Stein's method resulted in failure.
ıe object of this paper is to describe a method of obtain-
ɔhotographs of minute vibrations on a magnified scale.
plane mirror of steel, A, is supported by its axis in the
l frame B. The ends of the axis are conical, and carefully
l into sockets in the ends of the screws C, C. On the back
e mirror is a slight projection D pierced by a small hole.
ıe vibrating disc, as hitherto employed, is a circular plate
rrotype iron, 2¾ inches in diameter, screwed to the back of
ɔphone mouth-piece of the form
ıted by Professor John Peirce,
now universally used. From
ɔenter of the back of this disc a
steel wire projects, the end of
h is bent at a right angle. This
serves to connect the vibrating
with the mirror by hooking into
ıole in D, as represented in the
e. The mirror frame and the
ıting disc are kept in a fixed re-
ı to each other by a block of hard wood, to which both are
y screwed. The mirror is set with its axis parallel, and its
ɔting surface perpendicular, to the vibrating disc.



Back view of Mirror, actual size.

heliostat sends a beam of sunlight horizontally through a
l circular opening. This beam passes into a dark closet
ıt a distance of several feet from the circular opening falls
the mirror above described placed with its axis inclined
o the horizon. The rays, reflected vertically downward,
through a lens at whose focus they form an intensely lumin-
mage of the circular opening.
carriage moving smoothly on four wheels travels beneath
ɔns at such a distance that the sensitized plate laid upon it
s at the focus for actinic rays. A uniform velocity is given
ıe carriage by a string fastened to it and passing over a
y. To this string a lead weight, just sufficient to balance
on, is permanently attached, while a supplemental weight
ıt the beginning of motion and is removed just before the
tized plate reaches the spot of light above described.
ıe velocity attained by the carriage is determined by plac-
ı sheet of smoked glass upon it and letting it run under a

tuning fork (Ut 3—512 v. s.) provided with a pointed wire. In every case more than 200 vibrations were counted and measured, and careful comparisons made between the earlier and later ones, so as to be certain of the uniformity of the motion.

From the description it will be evident, that when the carriage alone is in motion a straight line will be photographed upon the plate. On speaking into the mouth-piece the disc is set in vibration, each movement causing change of angular position of the mirror, the reflected light moves through twice this angle, and the resulting photograph gives us the combination of its motion with that of the carriage.*

The general character of the curves obtained is shown in the accompanying figures, which are about one-half (0·56) the actual size of the originals. The reduction was accomplished by photography on the wood itself, so that the skill of the engraver was employed simply to follow the lines, which he has done with great fidelity.

The velocity of the carriage for the vowel-sounds was 21½, for *Brown University*, 40, and for *How do you do*, 14 inches per second.

In the mathematical discussion of these curves the abscissas are measured by the known velocity of the carriage, and serve to determine the *pitch*, the ordinates represent the amplitude of vibration of the center of the disc, magnified 200 times in the photographs. The reduction of scale makes the magnifying in the wood-cuts only 112 times.

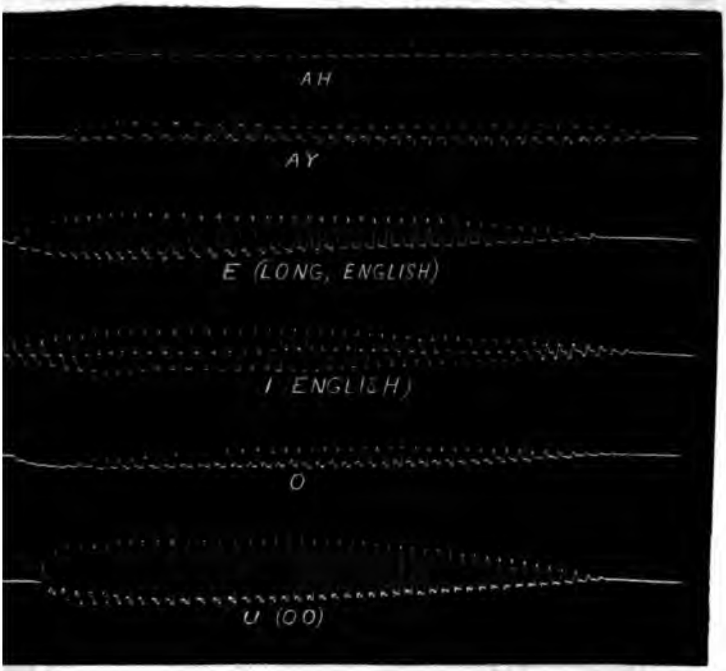
The ordinates are not strictly straight lines, but parts of the vertex of a parabola, and closely approximate to circular arcs whose radius is the focal length of the lens employed.† In the figures given, the centers of curvature of these arcs is at the right hand.

With an ordinary tone of voice an amplitude of nearly an inch is obtained, implying a movement of the center of the disc of ·005 inches as determined by actual measurement.

By varying the accelerating weight and its fall, any manageable velocity may be given to the carriage. Each syllable requires for its articulation about one-fourth of a second, hence

* The carriage should run from *right* to *left*. The negative (examined from the *glass* side), and prints taken from it, then give the syllables in their proper order, and show movements of the disc from the speaker by lines going from the observer. The arrangement of my dark room compelled me to make my carriage move from *left* to *right*; hence, in the figures given, forward positions of the disc are represented by the lower portions of the curves.

† It can easily be shown that the reflected beam describes the envelope of a cone, whose apex has an angle of 90°, and whose axis is inclined 45°. The intersection of this cone with the horizontal plane gives the parabola. The lens employed transfers the apex to its own optical center. The ordinates may be made practically straight lines by placing the mirror with its axis vertical so as to reflect the beam *almost* directly back on its path, and having the sensitized plate move up and down in a vertical plane.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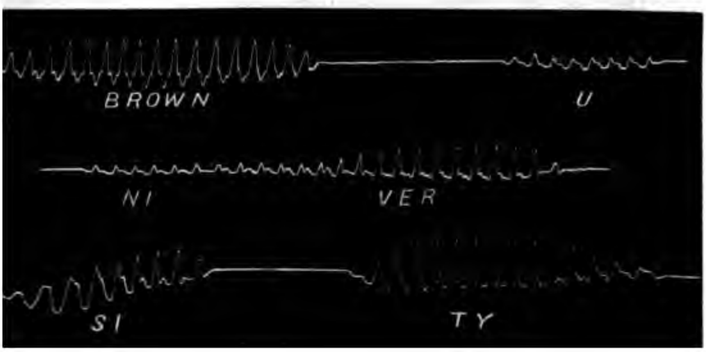
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the plates must be quite long when the velocity is great. I employ plates two feet in length, and find that velocities from 16 to 40 inches per second give good results. The action of the light is however inversely as the velocity. To compensate for this, the size of the circular opening admitting the light may be increased. This, of course, causes an enlargement of the luminous image, and apparently involves an injurious widening of the line traced, but, as observed by Dr. Stein in his experiments, the effect of velocity is to narrow the line photographed, since the maximum exposure is in that diameter of the circular image which lies in the line of motion. This is a great advantage, since a variation of velocity in the vibration is marked by the widening of the line, often more clearly than by the form of the curve.

I have employed the ordinary photographic process, not attempting to obtain special sensitiveness. The brightest sunlight is required, a slight haziness interfering seriously with the result. My heliostat employs two reflectors of ordinary looking-glass, and the loss of light is considerable.

To guide those who may wish to try this method I add the following measurements:

Diameter of circular opening .... $\frac{3}{4}$ $\frac{7}{16}$ inches.*
Distance of mirror from circular opening .... 28 feet.
Distance of mirror from photographic plate ... $11\frac{1}{2}$ inches.
Focal length of lens .... $9\frac{1}{4}$ inches.
Size of steel mirror .... 0·46x0·34 inches.
Weight of steel mirror .... 0·065 gram.

The question naturally arises whether the mirror may not so interfere with the vibrating disc as to destroy its articulation. The telephone gives a direct answer and banishes the doubt. The mirror was attached in the manner already described to the disc of a telephone, and the instrument showed itself still perfectly capable of 'sending,' and 'receiving,' without noticeable loss of clearness or quality.

Are *all* the audible elements of speech traceable in these records? in other words, is the record complete? I am not prepared as yet to answer this question definitely, but the following experiment leads me to doubt whether an affirmative answer can be given, while at the same time it illustrates in a striking manner the sensitiveness of the ear. The mirror was attached to the disc of a *receiving* telephone and a photograph taken from it while the instrument was talking audibly. The resulting record was almost a smooth line, showing but very slight indications of movement of the mirror. It would therefore, appear that there are distinctly audible elements, which

* Depending on velocity required, and on actinic intensity of the light.

are too minute to be recorded by this method. It is to be noted, however, that the width of the line traced where the vibrations are extremely small, is so great as to mask the curvature, so that the experiment just cited is not entirely fair.

The clearness and beauty of the curves obtained can hardly be appreciated without inspection of the originals. Their complexity and variety open a large field for investigation, and they seem to offer the means of analysis of articulate speech.

ART. VIII.—*Suggestions for a Telephonic Relay;* by Professor O. N. ROOD.

AFTER reading an account of the experiments of Mr. Hughes,* which may be regarded as an extension of the work of Edison, it occurred to me that the peculiar property of carbon, upon which they depend, might be utilized in the construction of a telephonic relay. I accordingly arranged three pieces of carbon in the form of an H, attaching the two outside pieces to the diaphragm of an ordinary telephone; this, with a battery, was destined to act as relay and re-transmitter. The first circuit included, then, a common telephone as sender, and the coil of the relay; the second included battery, vibrating carbon, and a common telephone used as a receiver. It was found that the vibrations of the pivots of the central piece of carbon were indeed able to modulate an electric current, so as to reproduce with somewhat diminished intensity sounds uttered in the sending telephone. Eight small vibrating carbons were now substituted for the single piece, and the reproduction was effected without loss of intensity or distinctness. The battery used with the relay consisted of eight small cells of zinc and carbon placed in diluted sulphuric acid only. For a relay to be efficient it is of course necessary that it should increase the loudness of the sounds so as to allow for electrical re-transmission to a more distant station; this can probably be effected, 1st, by making the telephonic relay of such dimensions that six or eight carbons can be placed approximately over the center of the iron diaphragm, and 2d, by using simultaneously several of these pieces of apparatus in the same circuit.

An arrangement like Hughes's microphone was also employed as sending instrument; an inverted coverless cigar box was used, on which I placed three vibrating carbons instead of a single one. The multiplication of the carbons was due to a suggestion of Dr. W. Gibbs, who at the time proposed various

* Nature, May 16, 1878.

forms of sending apparatus, all including the principle of multiple vibrating points or surfaces of contact. This simple apparatus was very sensitive, and reproduced with fidelity conversation in a low tone at a distance of more than thirty-five feet from the box; its performance suggested to me the multiplication of the carbons on the relay.

To the above I may add that when the electrical current used with the carbons is too powerful, a hissing, crackling sound is produced, which is from time to time varied by the introduction of a pure musical note, which often runs through considerable variation in pitch. This voltaic tone may be due to the repulsion exerted by the electrical current on itself, causing one of the carbon points to rise and fall with regularity in a manner analogous to the motion of the Trevelyan rocker, or it may be caused by rapid changes in temperature and hence in volume of the contact-surfaces. With fourteen small cups it occurred quite frequently.

Columbia College, June 10, 1878.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Microphone of Hughes.*—At the meeting of the Royal Society on May 9th, Professor Huxley presented a paper by D. E. Hughes of London, on the action of sonorous vibrations in varying the force of an electric current.* The results described were obtained in an attempt to investigate, by means of the telephone, the effect of sound vibrations on the electrical behavior of matter. Using a Daniell battery of three cells, with a telephone in circuit, the wire conductor was subjected to strain until it broke; no sound was heard except at the instant of rupture. It was then noticed that the sound could be reproduced on making and breaking the circuit with the broken ends of the wires, or even more simply by connecting the wires with two nails placed side by side, a third lying upon them at right angles breaking or lessening contact whenever subjected to jar, even by sound waves. Ten or twenty nails piled up log-hut fashion, increased the effect, and a piece of steel watch chain worked very well. Still better results were obtained by the use of a metallic powder in a glass tube, the instrument in this form being so sensitive as to reproduce articulate speech. All finely divided conductors which do not readily oxidize, such as platinum, mercury and carbon, or still better metallized carbon (willow charcoal heated to whiteness and plunged into mercury) may be used for the purpose, a glass tube filled with such substances, and provided with wires for insertion in a

* Engineering, xxv, 369, 384, May 10 and 17, 1878. Sci. Am. Suppl. v, 2024, June 8, 1878.

circuit, being called a "transmitter." Exposed to sound, even when quite inaudible to the unaided ear, the resistance of the transmitter varies in consequence of the vibration, thus varying the current strength and producing in the telephone a distinct noise. The slightest touch on the table where it is lying, the merest contact with a feather or a camel's hair brush, is distinctly heard in the receiver, and both instrumental and vocal sounds are transmitted with power. Acting on these facts, Hughes devised an instrument especially adapted for magnifying weak sounds, to which he gave the name microphone. It consists simply of a piece of gas carbon, an inch long, ¼ inch wide at the center, and ⅛ inch thick, pointed at the ends and supported vertically between two blocks of the same carbon which have small cavities hollowed out to receive it, the upper end being more blunt than the lower, and rounded. The weight of the upright piece is only just sufficient to make a feeble contact. With this form of transmitter the beating of the pulse, the tick of a watch, the tramp of a fly can thus be heard at least a hundred miles from the source of sound. In explanation of these facts, the author says: "It is quite evident that these effects are due to a difference of pressure at the different points of contact and that they are dependent for the perfection of action upon the number of these points of contact. They are not dependent upon any apparent difference in the bodies in contact but the same body in a state of minute subdivision is equally effective."

The results which have been obtained by Hughes as above described, are clearly anticipated by more than a year by those of Edison.* In January, 1877, while engaged in perfecting an articulating telephone, Edison made use of the fact discovered by him in 1873, that semi-conductors have the peculiar property of varying their resistance with pressure. To the center of a diaphragm was attached a spring faced with platinum, in front of which, and movable by an adjusting screw, was a small cylinder of graphite. This arrangement gave great volume of sound but its articulation was poor. After extensive experimenting, using the graphite mixed with various substances, lead peroxide, copper iodide, pulverized gas retort carbon, manganese peroxide, amorphous phosphorus, finely divided metals, many sulphides, tufts of silk fiber coated with metals by chemical means and pressed into disks, etc., he was led to adopt a disk made of the lampblack from petroleum smoke and to use it in the primary circuit of a small induction coil. This constitutes the carbon telephone, which, certainly for long circuits is the loudest transmitter known. In June, 1877,† he described a new form of relay based on the principle of varying resistance by pressure, using disks of carbon on the poles of the receiving electro-magnet, on which disks the armature rested. The coils of this magnet were in the primary circuit, the cores,

*The Speaking Telephone, Talking Phonograph and other novelties. By George B. Prescott. pp. 431, 8vo. New York, 1878. D. Appleton & Co.

†Journal of the Telegraph, x, 163, June, 1877.

disks and armature in the secondary. When a current passed through the magnet, the armature was attracted, compressed the carbon disk, diminished its resistance, and so increased the current strength in the secondary circuit. Since the diminution of the resistance is exactly as the pressure, the relay translated the varying current strength of the one circuit into a varying current strength in the other, of precisely similar character; thus for the first time making it possible to relay telephone currents. That the effects thus obtained by Edison are due simply to varying external contact, was first proved by C. B. Richards of Hartford in July, 1877. Placing a graphite cylinder between the jaws of a vise, platinum battery-contacts being provided at the ends, he found that the resistance of the cylinder to an electrical current diminished as the jaws of the vise were brought together, exactly as asserted. But if, in place of contacts at the ends, the connections were made by winding platinum wire round the cylinder just inside the ends, no variation of the galvanometer deflection was observed on increasing the pressure; thus proving conclusively that the phenomenon discovered and utilized by Edison depends upon the simple fact that a great variation in the resistance of a semi-conductor takes place on varying the surfaces of contact by pressure, the variation of resistance being directly as the pressure exerted.

It would seem sufficiently evident that the phenomena, of Hughes and Edison alike, are due to the varying resistance of an electrical circuit at the point or points of contact. The correctness of this explanation is proved by the increase of the effect with multiple contacts. This is accomplished by Hughes with finely divided materials such as metallized carbon, or metallic filings or carbon fragments in a glass tube; and by Edison by layers of silk covered with graphite, by several cylinders of graphite placed in a row, or by increasing the surface of his carbon button. The extreme sensitiveness of the Hughes apparatus is fully equalled by that of Edison, all the phenomena described with it being readily repeated with Edison's carbon transmitter, especially if a carbon button be used which has been worked over several times so as to be in a state of minute division. The tick, the brush, the fly tramp can all be heard with it. For purposes of practical telephony, however, this sensitiveness is a serious objection, and was overcome by Edison only after long experimenting. It is mainly a matter of adjustment of the contact pressure, as well in the carbon telephone as the microphone, the apparatus being the more sensitive the less the pressure. Moreover, the fact that Hughes transmits speech without the use of a diaphragm does not affect the question. Edison months ago replaced the vibrating diaphragm of his telephone by a plate of metal rigidly attached to the carbon, and serving to increase the loudness by increasing the surface on which the sound acts. This, however, is not at all necessary. It is easy to talk with the carbon transmitter of Edison, by projecting the sound waves directly against the carbon itself as in the microphone. Finally, Edison has utilized the varying resist-

ance of carbon contacts by pressure, in the construction of an apparatus by which minute differences of pressure may be measured, and has applied it to the construction of a thermometer, barometer, and hygrometer of extraordinary delicacy, and to the production of a rheostat of great simplicity. G. F. B.

2. *On the Boiling Point of Sulphuric acid of various strengths.*—Though the boiling point of the most concentrated sulphuric acid—containing 98·5 per cent H_2SO_4—was carefully fixed by Marignac at 338°, no determination of the boiling points of acid of less concentration has been made since Dalton. LUNGE has undertaken to redetermine accurately these boiling points by the following method: About 150 c.c. of the acid to be examined was placed in a flask having a long and wide neck and heated to boiling. In the flask the thermometer was so suspended by wires of platinum as to maintain a central position, the bulb being wholly immersed in the liquid. Since by loss of water the strength of the acid is increased, the boiling point must be determined at the beginning of ebullition. This the author takes to be the instant at which the stem of the thermometer is surrounded by transparent vapors, and a partial condensation takes place on the neck, the thermometer becoming at the same time stationary for from a quarter to half a minute. In this way, an accuracy of half a degree may be attained. The density of the acid was determined by direct weighing and reduced by Bineau's formula to 15°. The percentage of H_2SO_4 was obtained from this by interpolation in Kolb's tables below sixty-three, and in Bineau's above this percentage. Plotting the observed boiling points as ordinates and the percentages of H_2SO_4 as abscissas, a curve is obtained which is very nearly a parabola and by which the boiling points may be obtained for intermediate strengths.—*Ber. Berl. Chem. Ges.*, xi, 370, March, 1878. G. F. B.

3. *Substitution of Sulphur for Oxygen in the Fatty Series.*—In the formula $C_nH_{2n+1}COOH$, which represents the acids of the fatty series, the oxygen of the carboxyl group may be partly or wholly replaced by sulphur, giving rise to three series of bodies, $C_nH_{2n+1}CSOH$, $C_nH_{2n+1}COSH$, and $C_nH_{2n+1}CSSH$, the first two of which are isomers. The confusion in naming these bodies is avoided by adopting the suggestion of Wurtz in his Dictionnaire de Chimie, and prefixing *sulpho* to the name of the acid when the oxygen in the carboxyl is replaced by sulphur, as in the first formula above given, *thio* when the oxygen of the hydroxyl is thus replaced, and *thio-sulpho* when both suffer substitution. Only the second of these classes has been yet produced, thio-acetic, thio-propionic and thio-valeric acids having been studied. DUPRÉ has succeeded in producing a member of the first series, sulpho-propionic acid, by the action of sodium sulphydrate and hydrogen sulphide upon ethyl cyanide, the materials being placed in a flask with an inverted condenser, and heated on the water bath for five or six days. The flask contained two layers of liquid, the upper one of which was a solution of sodium sulphydrate.

On decanting this, an oily liquid remained, which on cooling became a crystalline mass; and this after purification gave on analysis the formula C_3H_5OSNa,H_2O. To establish the constitution of this body, nothing more is necessary than to convert the hydrate into the chloride, and see if the chloride contains sulphur; as this, of course, could not be the case if it is the hydroxyl oxygen which is replaced. For this purpose the sodium salt was treated with phosphoric oxychloride, and a chloride of sulphopropionyl $C_3H_5S\,.\,Cl$ was obtained, though in minute quantities. Sodium sulphopropionate, C_2H_4CSONa, is very soluble in water and gives with lead acetate a white precipitate permanent in the cold; which distinguishes the sulpho from the thio salt, its isomer, which blackens at once. The barium salt was also obtained.—*Bull. Soc. Ch.*, II, xxix, 303, April, 1878. G. F. B.

4. *On the Synthesis of Oxindol.*—The conception that isatic acid is orthoamidophenylglyoxalic acid and that isatin is its anhydride, was first enunciated by Kekulé in 1869, who announced his intention to prepare orthoamidophenylacetic acid, and from this by oxidation to produce isatin. BAEYER has now succeeded for the time in preparing orthoamidophenylacetic acid, and in showing its ready conversion into oxindol. That oxindol is really the anhydride of orthoamidophenylacetic acid was proved by Suida, who, at Baeyer's suggestion, examined the question whether, in the reduction of isatin to oxindol, one or two CO groups were attacked, and if only one whether it was that group which was attached to the benzene, or the other one. On analytical grounds, the formula $C_6H_4\left\{\begin{matrix} CH_2CO \\ | \\ NH \end{matrix}\right.$ was established for oxindol, thus answering the problem. The synthesis of oxindol is extremely simple. Phenylacetic acid is nitrated by means of fuming nitric acid, producing nitrophenylacetic acid. This is reduced with tin and hydrochloric acid to amidophenylacetic acid. The acid liquid is neutralized with marble and boiled with precipitated barium carbonate. The isomeric amido-acids form barium salts, with the exception of the ortho-acid, which decomposes into its anhydride, and remains in the solution, from which the pure oxindol is extracted by ether. It fuses at 120°, yields indol when reduced with zinc dust, and yields the well characterized color reaction of nitrosoxindol with nitrous acid.—*Ber. Berl. Chem. Ges.*, xi, 582, April, 1878. G. F. B.

5. *On Aldehydines, a new Class of Bases.*—LADENBURG has given the name aldehydines to a class of basic bodies formed by the condensation of one molecule of an orthodiamine and two molecules of aldehyde, with the separation of two molecules of water. For the preparation of tolubenzaldehydine, a mixture of one molecule of ortho-toluyl-diamine and two molecules of benzaldehyde is heated to 140° in open vessels for eighteen hours. The resulting mass is dissolved in hot alcohol, and on cooling yellow crystals separate, which, dissolved in hot dilute hydrochloric acid, yield long colorless needles of the hydrochlorate of the new base. Decomposed by ammonia, the base itself is obtained, and

is purified by recrystallization from alcohol. It fuses at 195·5°, crystallizes in clear colorless monoclinic prisms, sublimes in small quantities, is insoluble in water, but soluble in alcohol and acetone, and in dilute acids. Its formula is $C_{21}H_{18}N_2$. Heated with ethyl iodide to 120°, yellow crystals of tolubenzaldehydine-ethyl iodide are obtained; and these treated with silver oxide, yield a strongly alkaline solution from which on evaporation an oil separated which could not be crystallized. Oxidized with permanganate, it gives dibenzenylamido-benzoic acid, $C_6H_3COOH(NC_7H_6)_2$. Hence, the author assigns to tolubenzaldehydine the probable rational formula

$$C_7H_6\left\{\begin{array}{l}NCC_6H_5\\ \times\\ NCC_6H_5\end{array}\right.$$

. Tolufurfuraldehydine, and tolusalicylaldehydine—to which he gives the special name azurine because of its magnificent blue fluorescence—are also described.—*Ber. Berl. Chem. Ges.*, xi, 590, April, 1878. G. F. B.

6. *On the Preparation and Properties of Invertin.*—Barth has investigated exhaustively the substance which is the inverting constituent of yeast, and which Donath called invertin. To prepare it, compressed yeast, freshly prepared, is coarsely pulverized, spread out in a capsule, and dried at a temperature not exceeding 40°, until it can be rubbed to a fine powder between the fingers. It is then heated on an air bath to 100° to 105° for six hours, mixed with water to a thin magma, allowed to stand for twelve hours at 40°, strained, and then filtered. The clear yellowish filtrate is poured into five or six times its volume of 95 per cent alcohol, by which a white flocculent precipitate is produced, which by strong agitation becomes granular, and may be easily filtered off. To free the ferment from albuminates—which this treatment with alcohol renders insoluble in water—the precipitate is freed from alcohol by pressure, digested in just sufficient water for solution, and filtered; the albuminates remain on the filter as a gelatinous mass. On pouring the filtrate into alcohol, the ferment is precipitated in the pure form. It is filtered off, washed with absolute alcohol at least ten times, the excess of alcohol expressed, and the precipitate dried in vacuo. The yield is about two grams from five hundred of yeast. Invertin thus obtained is a white powder, giving a clear yellowish-brown neutral solution with water, which, boiled with acetic acid and salt, is not rendered turbid, showing that it is neither an albuminate itself nor contains one as an impurity. Boiled with dilute copper solution and sodium hydrate, no violet color appears, showing the absence of peptones. No leucin could be detected on long boiling with sulphuric acid. On analysis it yielded 22 per cent of ash, consisting of potassium, calcium and magnesium phosphates. Calculating this out, it contained carbon 43·9 per cent, hydrogen 8·4 per cent, nitrogen 6·0 per cent, sulphur 0·63 and oxygen (by loss) 41·17 per cent. Experiments on the activity of invertin, using cane sugar solution, showed that it is dependent on the concentration of the sugar solution, is proportional to the quantity of the ferment

present, reaches its limit in about forty hours, and that one part of invertin produces 760 parts of inverted sugar as a maximum.—*Ber. Berl. Chem. Ges.*, xi, 474, March, 1878. G. F. B.

7. *On the occurrence of Allantoin and Hippuric acid in the Urine of the Dog.*—SALKOWSKI has confirmed fully the statement of Meissner that both allantoin and hippuric acid occur in the urine of the dog. In the attempts to dissolve the crystalline residue of the evaporation of the urine of a dog in cold water, he noticed that a not inconsiderable mass remained undissolved. By recrystallization from hot water, crystals of pure allantoin were obtained. The amount given was 0·8 gram from the urine of four days, the dog being fed on meat. The hippuric acid was detected in the urine of the four days' experimented with, when hungry, when fed on meat, and when the intestine was ligated. As a maximum it reached one one hundred and twenty-ninth of the urea. It was never entirely absent, even when no food or only purely animal food was given; and the ligation seemed to be without influence.—*Ber. Berl. Chem. Ges.*, xi, 500, March, 1878. G. F. B.

8. *On the Coloring Matter of the Shells of Birds' Eggs.*—The brilliant and remarkably permanent color of the eggs of many birds has led LIEBERMANN to the investigation of its cause. He finds that however widely different these colors are from each other, they are due essentially to but two coloring matters, one a blue or green substance, probably a biliary coloring matter, the other characterized by a remarkable absorption spectrum. These coloring matters are contained in the superficial layer of the shell, often in several thicknesses. When the shell is treated with dilute hydrochloric acid, the coloring matter separates in flocks, and by treatment with alcohol a strong solution may be obtained. With the eggs of gulls and plovers, an unsuccessful attempt was made to obtain the coloring matter pure. The colored alcoholic solution shows two sharp absorption bands, one on each side of the D line, when strongly acid. When alkaline, four weaker bands appear, none of which are coincident with the first.—*Ber. Berl. Chem. Ges.*, xi, 606, April, 1878. G. F. B.

9. *Chemistry in Space.* — Speculations on the forms of molecules and the arrangement of the atoms in space are generally as useless to the scientific world as they are entertaining to their authors, and are therefore almost exclusively confined to fanciful chemists, like J. G. McVickers, D.D., LL.D., who draw from their imaginations most beautiful and symmetrical pictures of molecules, which resemble nothing earthly unless those many-angled ornaments made of straw or perforated card-board so common in the windows of farmhouses. The pamphlet on "Chemistry in Space" recently published by Van't Hoff must not be confounded with these amusing but unprofitable examples of the so-called chemistry of the future, as its sole object is to establish a theoretical explanation of those cases of isomerism, usually called physical, and not accounted for by our present plane chemical formulas. Its importance is shown by a most complimentary preface written by Wislizenus for the German edition, and perhaps quite as well

by a violent criticism from the great chemical Ishmaelite, Kolbe, who never deigns to attack any but the most important theories. The principal points made by Van't Hoff may be stated briefly as follows: *First.* If the four affinities of an atom of carbon project from it toward the angles of a regular tetrahedron, and each of these affinities is satisfied by a different radical, two isomers are possible (instead of none as predicted by the same formula conceived as a plane figure) because there are two arrangements of these radicals which cannot be made to coincide by any change of position. One of these stands to the other in the same relation as that of any object to its image in a looking-glass. For example, one of the carbon atoms in laché acids is attached to four different radicals (CH_3, COOH, H, HO), and we find two laché acids accordingly, one from milk, the other from flesh, resembling each other in chemical relations most closely, but differing in physical properties. *Second.* In unsaturated compounds where two carbon atoms are united along one edge of the tetrahedra, two isomers are possible, if the two free affinities in each carbon atom are satisfied by different radicals; for instance in maleic and fumaric acids each carbon atom is attached to COOH and to H; if the two carboxyls are adjacent we have maleic acid, thus accounting for the ease with which its anhydride is formed, while in fumaric acid each carboxyl is adjacent to a hydrogen atom,

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               HOOC H                      HOOC H
                  V                           V
                  C                           C
Maleic acid,      ‖          Fumaric acid,    ‖
                  C                           C
                  Λ                           Λ
               HOOC H                        H COOH
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This is certainly a simple and probable explanation of this puzzling case of isomerism, which drove Fittig in his recent classical work on the unsaturated acids to the undesirable assumption of a bivalent carbonatom as the only explanation possible on the old theories. *Third.* The phenomena of circular polarization can be explained by a spiral arrangement of the different radicals attached to a carbonatom; according as this screw turns to the right or the left would the plane of polarization be deflected in one or the other direction; while two atoms with opposite spirals in the same molecule would give an inactive substance. By this hypothesis the different forms of tartaric acid and the differences between dextrose and levulose can be fully explained.

The limits of this notice, and the absence of figures, render it impossible to do justice to this extraordinary little pamphlet of Van't Hoff's, which will richly pay the trouble of reading, as there can be no doubt that it contains a large and important addition to our chemical theories, and marks out a great number of new lines for experimental work.* C. L. J.

* La Chimie dans l'Espace, J. H. Van't Hoff. Rotterdam, 1875. Translated by F. Hermann as Die Lagerung der Atome in Raume. Vieweg und Sohn. 1877.

10. *Studies in Spectrum Analysis;* by J. NORMAN LOCKYER, F.R.S. 258 pp. 8vo. New York (D. Appleton & Co.—International Scientific Series).—Professor Lockyer's name has been so long connected with the subject of spectrum analysis that a new work by him can hardly need commendation. The book commences with a theoretical explanation of sound-waves, and light-waves, and goes on to explain the methods of demonstrating spectrum phenomena. Other chapters are devoted to spectrum photography, the spectra of salts, dissociation, quantitative spectrum analysis, results of the study of the sun with the spectroscope, and other kindred subjects. The work is a collection of interesting essays written in a clear and simple style, with excellent illustrations, and embodying what is newest in this branch of science. Taken together, however, the subjects are somewhat wanting in connection.

II. GEOLOGY AND MINERALOGY.

1. *On Terrace Levels in Pennsylvania;* by Prof. J. P. LESLEY, Director of the Pennsylvania Geological Survey. Letter to J. D. Dana, dated Philadelphia, May 27, 1878.—In my preface to Prof. I. C. White's Report of Progress Q on Alleghany, Butler and Beaver Counties lying on the north side of Ohio river, in Western Pennsylvania, I have ventured to discuss the character of the terrace deposits along that river, and along the Monongahela river; not with any hope of solving one of our hard problems, but to place a provisional picture of the facts, thus far collected by Prof. Stevenson and Prof. White, before the attentive consideration of other gentlemen, engaged in the study of our surface deposits in other districts of the State. What opinions I ventured with much hesitation to express were not entirely approved of by Prof. Stevenson and Prof. White, who had the best right in the world to their view because so familiar with the field. My own opinions were based, however, not only on the phenomena exhibited there, but on a large body of facts exhibited in other parts of the State. And yet I hold them very lightly; for there is a great deal still to be learned before the order, extent and nature of the events of the Champlain period can be made out satisfactorily.

I drew the contour curve of 1,300 feet above tide around the sides of all the valleys of Western Pennsylvania, to see how a submergence of that magnitude would account for the terraces (or some of them) and for the distribution of the perched azoic blocks, confined geographically to the country west of the Beaver River and north of the Ohio; and I concluded that a submergence to that extent was probable; also, that the upper clay terraces represent the sloping plains of mud which during that submergence were deposited in the valleys, by ordinary deposit from the surrounding and intervening coal-measure high lands. I have (it is needless to say) always considered our whole topographical sculpture nearly accomplished and finished previous to the com-

mencement of this era of late and temporary submergence; and I am still unable to see any need for changing my old views. I still believe that the valleys have been refilled and are being reëxcavated; the terraces being only residual strips of Champlain clay left clinging to and upon older rock-terraces worn by the ancient erosion out of the hard and soft horizontal layers of the coal-measure mass.

I have just received a letter from Prof. White, announcing an important discovery bearing weightily upon the subject in question, made by Prof. Foutaine and himself about two miles from Morgantown in West Virginia. Here a broad level reach of country, called the Flats, extends from two to four miles back from the Monongahela river, toward the east, and south of the Pennsylvania State line. When critically examined, the whole area of the Flats was found to be "covered to an unknown depth with a very fine, tough, aluminous, creamy-white clay, containing immense numbers of vegetable remains in the most perfect state of preservation of which it is possible to conceive." Only a small collection has as yet been made and a few weeks must elapse before a sufficiently large collection can be made to decide the point how far the plant-forms differ from those of our present local flora.

The top of the deposit is about 300 feet above the river, which would make it more than 1,200 feet above tide. English geologists would be very apt to suggest a glacial dam at Pittsburgh to account for such deposits in the water basin of the Monongahela River. But there is no such short cut to an explanation of a phenomenon coëxtensive with half a dozen States of the Union.

Mr. White says the level of the Flats must be about the same with that of the pottery-clays so extensively worked at Greensboro and Geneva in Fayette County. He adds that on the "Second Terrace" (of Prof. Stevenson's series) below Morgantown, Mr. Keek in sinking a well 70 feet deep, passed through continuous silt and clays, and no rock. Prof. Stevenson's third Report of Progress (lettered KKK) is just coming from the press, and will be read with great interest by geologists who busy themselves with the more recent deposits.

2. *Cretaceous and Tertiary of Charleston, S. C.* -- Lieutenant A. W. Vogdes, U. S. A., in a communication to the Charleston News and Courier for April 9th, states that in the Artesian boring at the Citadel, Charleston, the Cretaceous formation was reached at a depth of 950 feet, where occurred *Exogyra costata*, and other fossil shells, among them a new Chama, which he names *Chama Charlestonensis*. The *Exogyra* continued to be brought up to a depth of 1,825 feet, and with it at the lower depth were obtained *Ptychodus Mortoni*, *Gryphæa Pitcheri*, *Ostrea cretacea*, etc. The present depth of the well is 1,870 feet, and Lieutenant Vogdes believes that they are at work in the "second bed of the Cretaceous above the underlying granite, specimens of water-worn gravel and sand of decomposed granite

now being brought up;" and that the whole depth from the surface to the granite will probably be found to be 2,000 feet.

The overlying Eocene consists of the *Lower* Eocene or Buhrstone group, which has a thickness at Aiken of 200 feet and rests on the granite, and of 250 feet at Charleston; the Middle or Santee beds, which have a thickness of 300 feet at Charleston, and were formerly known as the Calcareous beds of the Charleston basin; and the *Upper*, which includes the Cooper and Ashley groups, about 300 feet thick in the Artesian boring. Next comes the later Tertiary, called by Lieutenant Vogdes Pliocene, which rests upon the Cooper group, and at Goose Creek is about 12 feet thick; it is stated to contain 45 per cent of recent shells.

3. *Yucatan Coral Reefs, and Cuba elevated Coral Rock.*—Prof. A. Agassiz, in his "Letter No. 1" on "Dredging operations of the U. S. Coast Survey, Schooner 'Blake,' during parts of January and February, 1878," describes the coral reefs of the Yucatan coast and land, and also the life of the sea bottom from there to the Florida Reefs. He states that the fauna of the Yucatan bank is identical with that of Florida. Alacran reef, on this bank, is an atoll, elliptical in form, about 14 miles long and 8 wide, with a depth of 1 to 6 fathoms inside, where are growing over the shallower parts "huge masses of *Astræa*, *Gorgonia*, *Meandrina*, and *Madrepora palmata*, which occasionally rise to the surface." The reef is steep to the eastward and slopes gradually to the westward. The structure is identical with that of the main Florida reef, and those of the northern coast of Cuba. In Cuba evidence of great elevation is seen in the existence of ancient coral reefs in the hills surrounding Havana and extending to Matanzas, these hills being 1200 feet high and consisting entirely of corals identical in species with those now living.

Large numbers of siliceous sponges were brought up on the Cuban coast, the *living Favosites*, "perhaps the most interesting coral ever dredged," together with many of the corals collected by Count Pourtalès on the rocky plateau south of the Florida reefs in 200 to 300 fathoms.

4. *The Richmond Bowlder Trains.*—These trains of bowlders, first made known by Dr. Stephen Reid, and described by Prof. Edward Hitchcock and later by Lyell, have been studied with care by E. R. Benton, and a description and map of them, with an excellent discussion of the facts, is contained in Bulletin Nos. 2–3, of vol. v, of the Museum of Comparative Zoology, Cambridge, 1878.

5. *Discovery of the Cleveland Shale in Delaware County, Ohio;* by L. E. Hicks, Prof. Nat. Sci., Denison University, Granville, Ohio. (Communicated.)—Among the subordinate questions connected with the Waverly group are those arising from the attempt to synchronise its sections in Southern and Central Ohio with that at Cleveland, upon which Newberry based his subdivisions. This section is as follows, beginning with the summit of the series:

Cuyahoga Shale	150to 250 feet thick.
Berea Grit..........................	60 feet thick.
Bedford Shale........................	75 feet thick.
Cleveland Shale................	21 to 60 feet thick.

Of these four members, so well and distinctively developed in Cuyahoga County, only the last uniformly retains its typical character in Central and Southern Ohio. It is everywhere a black bituminous shale containing scales, spines and teeth of fishes, and shells of a small species of *Lingula*. Not only is it uniform, but it is unique, both in respect to its fossils and its lithological characters. In the latter particular, it is true, it closely resembles the Huron shale (Devonian). *But the two never exist together in immediate contact.* In Northern Ohio they are separated by the Erie shale (Chemung); on the Ohio River by 147 feet of shales and sandstones of the Lower Waverly; and in Central Ohio by 75 to 100 feet of shales, siliceous limestone and sandstone.

On account of the great variations in lithological aspect of the other members, and the persistent uniformity of the Cleveland shale, the latter is the only reliable guide in determining the relations of associated strata. I have just made the discovery that an unmistakable outcrop of Cleveland shale exists two miles east of Sunbury in Delaware County, Southern Ohio, on the land of Horace Whitney. It lies *above* the calcareous sandrock of the Sunbury quarries, which Prof. N. H. Winchell, a special assistant on the Ohio geological survey, identified as *Berea grit*. My discovery *demonstrates* the incorrectness of that identification, and raises a strong presumption, amounting almost to a certainty, that he was equally wrong in respect to his Berea grit in Morrow and Crawford counties. I risk the prediction that the Cleveland shale will yet be found to the *east* of the supposed Berea at Mt. Gilead, Iberia and Leesville.

6. *Jurassic fossils in the Coast Range of British Columbia.* —Mr. J. F. Whiteaves has described the Jurassic fossils collected by Mr. G. M. Dawson, mostly from the vicinity of Iltasyouco River, a tributary of Salmon River, and Sigutlat Lake. The author concludes that nine of the twenty-eight species are identical with those of Jurassic rocks of Dakota described by Meek, namely: *Gryphæa calceola* var. *Nebrascensis*, *Camptonectes extenuatus*, *Eumicrotis curta*, *Modiola* (*Volsella*) *formosa*, *M. pertenuis*, *Grammatodon inornatus*, *Astarte fragilis*, *Pleuromya subelliptica*, *Planorbis veternus*. The other species include *Lima duplicata* Sowerby, *Stephanoceras Humphreysianum* Sowerby, *Pleuromya unioides* Rœmer, *Astarte ventricosa* Meek, a species described from Jurassic rocks of Nevada, *Trigonia Dawsoni* Whiteaves, also identical with a Nevada species, a *Belemnites*, etc. The species are stated to be probably either Liassic or Lower Oolite. Mr. Whiteaves remarks that the Upper Trias is known to extend from Mexico to British Columbia, and that *Monotis subcircularis* of Gabb has been found recently in the northern part of Vancouver Island, on Peace River on the mainland, and on

Upper Pine River east of the mountains; and that the Jurassic and Cretaceous seas were probably equally extensive; that some Texas Cretaceous species have been found in deposits of the same age on Peace River and on Vancouver Island; that during the Mesozoic there was no Rocky Mountain barrier separating the species east from those west.

7. *Thesaurus Devonico-Carboniferus; The Flora and Fauna of the Devonian and Carboniferous Periods*, with large Addenda (from recent acquisitions); by JOHN J. BIGSBY, M.D., F.R.S., F.G.S. 448 pp. 4to. London, 1878. (J. Van Voorst.)—Ten years have passed since the publication of the *Thesaurus Siluricus* by Dr. Bigsby; and now has appeared a volume still larger, and equally elaborate and complete, on the Devonian and Carboniferous Periods. Like the former work, it gives tables of the names of all known species of fossil plants and animals from the rocks of the formations under consideration, and these tables are so constructed as to exhibit the horizons of the species, their recurrences, localities, references to the places where described, and the synonymy of genera and species. In addition, the author lays down his deductions from a survey of the facts, describes sections of the Devonian and Carboniferous in Great Britain, various countries of Europe, and in other parts of the world; gives lists of the fossils of these countries, thirty in number, and a catalogue of the works and memoirs on the subject. The volume is hence most truly a "thesaurus," and will be so found by all American as well as other geologists. The author observes that the number of Silurian species known at the time of publication of his work (February, 1878) is about 9500, of Devonian 5600, of Carboniferous 8700.

Dr. Bigsby spent five summers in traveling through the Canadas, east and west, together with the State of New York and the States bordering on the Great Lakes, and the country northward to Hudson's Bay, and thus has had personal acquaintance with the older American rocks and their fossils, and also with many American geologists.

III. BOTANY AND ZOOLOGY.

1. *The Native Flowers and Ferns of the United States;* by THOMAS MEEHAN. Illustrated by chromo-lithographs. Boston: L. Prang & Co. Parts I and II, not dated, but issued in May, 1878. Each part with 4 plates and 16 pages of letter-press. Imp. 8vo. Published at 50 cents each.—From the title this work might be thought to be a combination of Isaac Sprague's Wild Flowers of America and Professor Eaton's Ferns of North America. But its aim is somewhat different. There is no attempt to rival the exquisiteness of these, and the size is smaller. The endeavor here is to give good figures at a wonderfully low price. In the work on Ferns we have three plates (many with two species) for a dollar; here we have four for half the money. And the publishers, the

well known firm of Prang and Company, have certainly done their work well, considering the price, which must increase rapidly with the number of stones used and the number of color-impressions necessary to give the right effect. If we judged the draughtsman from his representation of *Anemone nemorosa* we could highly commend his work. If we took those of *Gelsemium* and *Aquilegia chrysantha* as the type, we could do no such thing. But we have an idea that the artist, Mr. Alois Lunzer, is not to be judged by these, and that his capacity for improvement, already manifest, has not reached its limits. It costs the lithographers no more to work from first-class drawings, than from those of mediocre quality; and if they can afford to carry on the work at all at the present rate, it will doubtless be very popular; for it appeals to a large class, and supplies a felt want. It is not the scientific botanist who is addressed, so much as the numerous array of flower-lovers, who wish to identify the plants they cultivate or observe, and that in the readiest and to them the chief practicable way, namely, by a plate or picture.

The letter-press is suited to the plates by its equally popular character and aim; but Mr. Meehan brings in a good deal of botanical lore and some philosophical disquisition, for which he has a remarkable aptitude. He has well proved his capacity for such an enterprise as this; but the rate at which it is to proceed, calling for sixteen pages every fortnight, may task the powers of the most energetic. In the rapid and discursive writing it calls for, statements will often fall from the pen which need qualification or discrimination, such as that on the first page, in which Tournefort is joined with Linnæus as having "made botany simple by reducing the Latin names given to each plant to two, the generic and the specific." A semi-anachronism. On p. 20, describing the blossom of the Blue Violet, and referring to the spur-like appendages to the lower anthers, Mr. Meehan writes:

"Some have contended that the projection is used as a lever, which, on being raised by an insect in search of nectar, causes pollen to be thrown on the insect's back, and the pollen is thus taken to another, thus cross-fertilizing it; but as in this Violet the spur-membrane is so closely fitted to the 'lever' that it cannot work, it shows how wholly imaginary these speculations are." What is included in "these speculations" is not further explained. But this particular speculation is so out of keeping with the obvious facts that we are should think it not only "imaginary" but till now unimagined. Sprengel's speculations upon the relations of insects to the violet, as reproduced by Lubbock, contain nothing of this sort. His conjectures had the merit of being founded on genuine observations, have been in great part confirmed, and ought not to be set aside by silently coupling them with an absurd and "wholly imaginary" one.

Our criticism of details like these must be taken as expressive of our earnest desire that a work like this, which seems likely to succeed, and which has our best wishes, should be as free as possi-

ble from flaws and short-comings. High art and exact science we do not expect; but completeness and substantial correctness may be looked for. A. G.

2. *Monographia Metzgeriæ;* auctore S. O. LINDBERG.—A pamphlet of 48 pages and two plates (leaf-sections), 8vo; gives eleven species to this genus of *Hepaticæ*, besides two of Mr. Austin's admitted as subspecies. Separate issue of a paper in the Proceedings of the Fennian Society at Helsingfors. A. G.

3. *Bryineæ Acrocarpæ: Utkart till en Naturlig grupperung af Europas Bladmossor med toppoistande Frukt.* Program af S. O. LINDBERG. Helsingfors, 1878.—A sketch of a new and natural arrangement of the Acrocarpic Mosses. A. G.

4. *Ferns of Trinidad.*—Mr. AUGUSTUS FENDLER, who began his botanical work as a collector, thirty years ago, when he first explored the region of Santa Fe, New Mexico, and made an admirable and well known collection, and who afterwards made still larger collections in Venezuela, is now resident in the Island of Trinidad. He proposes to collect all the species of Ferns and fern-like plants of that rich tropical island, and to distribute them in sets. The first installment, containing complete and handsome specimens of 78 species, is just received in excellent condition. The price is $7.50 for a set. Application may be made to the Curator of Harvard University Herbarium, Cambridge, Mass. The species will speedily be named by Professor Eaton, of Yale College, and a printed list furnished. A. G.

5. *Flora Brasiliensis*, Fasc. 73, issued in October last, contains the *Lythraceæ*, by Koehne, of Berlin, a new collaborator, and apparently an able one. Under the genus *Cuphea*, of which the Brazilian empire contains seventy-four species, the editor has given a synopsis of all the known species, which will be very useful, as many are in cultivation. Dr. Koehne is probably quite right in his opinion that *Lythrum Hyssopifolia* is not indigenous to North America; also that two or three species are to be distinguished among the plants referred to *Lythrum alatum* Pursh, in Torrey and Gray's Flora of North America, and other works. He follows Hiern in restoring the genus *Rotala*, which includes *Ameletia*, *Suffrenia*, etc., and extends it to take in *Hydrolythrum* and *Rhyacophila* (*Quartinia*) also. Upon the propriety of this we are not ready to pronounce; but we are confident that the separation from *Ammania* ought not to be made simply on the difference in the dehiscence of the capsule and the number of flowers in the axils, thus throwing our two common United States species into different genera. Nor has *Ammania humilis* Michx., a cartilaginous capsule; it is really membranaceous and thin; but the nearly regular opening at the summit by short valves, instead of irregular lateral bursting, well distinguishes the species from the *A. latifolia*. As to the latter species, it still appears most probable that it includes both a form with subsessile stigma and prevailingly apetalous (*A. latifolia* of the Fl. Bras., *A. lingulata* Griseb, etc.,) and one with longer style (*A. sanguin-*

olentu Swartz, etc.,) which is usually petaliferous. It is to *A. arenaria* HBK. (which, as Koehne remarks, all subsequent botanists overlooked) that *A. Wrightii* Gray, belongs, and apparently *A. longipes* of Wright also. Fasc. 74 does not invite particular remark. It has the *Humiriaceæ* and *Lineæ* by Dr. I. Urban, also a new hand; and *Oxalidaeæ*, *Geraniaceæ*, and *Vivianiaceæ*, by Dr. A. Progel. The key to the 108 Brazilian species of *Oxalis* comprises also additional species of the adjacent regions. And a new genus of two species, allied to *Averrhoa*, is dedicated to Dr. Eichler, the excellent editor of this Flora. This fascicle is dated December, 1877; so that the present genus has priority over D. Hartog's *Eichleria*, which is perhaps a better marked genus. A. G.

6. *A Monograph of the Genus Lilium*; by HENRY JOHN ELWES, F.L.S., F.Z.S. Illustrated by W. H. Fitch., F.L.S. Folio. —Four parts of this truly magnificent contribution to Horticultural Botany have reached us. Mr. Elwes has long been known as a most successful and enthusiastic cultivator of lilies and other bulbous plants, and his collection of them is one of the most complete in existence. Not only has he been a most assiduous and enterprising collector of living plants, but he has known how to turn his collections to the best use, and is doing for *Lilium* what might, with equal advantage, be done for *Iris*, *Crocus* and *Gladiolus*, genera in which the limitation of species is attended with much confusion and difficulty. In *Lilium*, particularly, this difficulty has been largely increased by the fact that lilies have, for centuries, been favorite garden plants, and that many species have become so changed by long cultivation that it has been impossible to refer some existing forms to wild types without a thorough study of the whole genus, including all garden forms as well as their wild originals. This Mr. Elwes has undertaken, and his monograph will be found an indispensable aid to a better understanding of the genus.

Of the thirty-two plates, which have already appeared, six are devoted to North American species, those figured being *Lilium superbum*; *L. parvum* of Kellogg, which is rightly considered a species, and not a western form of *L. Canadense*, to which other European botanists have referred it; *L. pardalinum*, the figure very well representing Kellogg's typical plant, and not a variety, as Mr. Elwes supposes (but the synonyms as given for this species will require some further revision); *L. Humboldti*, a magnificent plate of one of the most distinct and beautiful of North American lilies; *L. Catesbœi; L. Philadelphicum*, and *L. Carolinianum*, which is considered as a species distinct from *L. superbum*, a view which is not shared by American botanists, whose previous opinion of this plant must be rather confirmed than otherwise by Mr. Fitch's beautiful drawing, which clearly represents a small form of *L. superbum*. Mr. Elwes notices as a curious fact "that all the American lilies, though varying remarkably among themselves, differ entirely in their bulb-structure from those of Europe and Asia, and the same peculiarity is noticeable

among the American species of *Fritillaria*, which, as far as we know them, have bulbs of small white and granular scales, loosely attached to a solid central axis from which the stem springs. Of all the Old World Lilies and Fritillaries, only two, namely, *Lilium avenaceum* and *Fritillaria Kamtschatkensis*, resemble their American congeners in the formation of their bulbs, and both of these are restricted in their geographical limits to the shores of Northeastern Asia, which have many affinities, both botanical and zoological, with the Pacific coast of North America." Each plate is accompanied by two or three pages of letter-press, containing a technical description of the species with a list of synonyms and references to other figures, as well as all available information in regard to its native habitat and mode of growth: also the history of its introduction into cultivation, and full cultural directions, derived from the author's own experience, and from that of the most successful lily growers of Europe. When completed the work will contain forty-eight colored plates, to which is to be joined an introductory chapter, containing wood-cuts of bulbs and other details, and a map showing the geographical distribution of the genus. C. S. S.

7. *Beiträge zur Keimungsgeschichte der Schizæaceen.* Dr. H. BAUKE. Extract from Pringsheim's Jahrbücher, vol. xi, 1878.—But little now remains to be studied with regard to the formation of the prothalus in the different suborders of Ferns. Not to speak of the numerous works on the development of the *Polypodiaceæ*, we have had within the last few years an account of the development of the genera *Osmunda* and *Ceratopteris* by Kny, and we noticed in the number of this Journal for March a paper by Gœbel, on the prothallus of *Gymnogramme leptophylla*. Junczewski and Rostafinski gave a description of the prothallus of Hymenophyllum in the Proceedings of the Cherbourg Society. In vol. x, of Pringsheim's Jahrbucher, Dr. Bauke gave an account of the prothallus of the *Cyatheaceæ* as compared with that of the other ferns, and that article is now supplemented by one on the germination of the *Schizæaceæ*. Dr. Bauke studied the germination in several species of *Aneimia* and in *Mohria Caffrorum*. He differs from Burch who has recently studied the development of the prothallus in *Aneimia* in several respects, and he does not consider that what Burch calls the "pousse latérale normale" is in any sense a lateral shoot, but simply that the formation of the cushion, in which the archegonia are produced, is in this case on the lateral margin of the prothallus rather than at the central sinus, as in the *Polypodiaceæ*. Bauke states that, although in general the prothallus of the *Schizæaceæ* differs from that of the *Polypodiaceæ*, yet there are numerous variations which connect the two suborders. W. G. F.

8. *Ueber die Aschenkrankheit und Blattflechenkrankheit der Citronenbäume;* by FELIX VON THUMEN.—The pamphlet bearing the present title is the latest contribution from the Experimental Station for the Culture of the Grape and Fruit at Klasterrænberg,

near Vienna. The botanist of the Station, Baron von Thümen, gives an account in Italian of two fungi, *Apiasporium citre* and *Sphærella gibelliana* which cause disease in the leaves of lemon trees. Another publication of interest is the list of fungi which are found on grape vines, of which the number of species is said to be 224. It must be remarked, however, that many of the species are not peculiar to the vine. W. G. F.

9. *Bulletin of the United States Geological and Geographical Survey of the Territories.* Vol. IV, No. 2. Department of the Interior.—This number of the Bulletin contains the following papers: The Geographical Distribution of Mammals considered in relation to the principal ontological regions of the earth, and the laws that govern the distribution of animal life, by J. A. ALLEN. Descriptions of new extinct Vertebrates from the Upper Tertiary and Dakota formations, by E. D. COPE. Catalogue of the Fishes of the fresh waters of North America, by D. S. JORDAN. Description of a fossil bird from Colorado, by J. A. ALLEN (see page 382, vol. xv, of this Journal). Coleoptera of the Alpine region of the Rocky Mts., by J. L. LECONTE. Orthoptera of Dakota and Montana, by C. THOMAS. Hemiptera of Dakota and Montana, by P. R. UHLER. Lepidoptera of Montana, by W. H. EDWARDS. Fossil insects from the Tertiary of Colorado and Wyoming, by S. H. SCUDDER. These fossils insects are a few out of a large number of species which Mr. Scudder has under examination. He remarks that those from the Florissant Shales of Colorado indicate strikingly a tropical relation. A fossil butterfly, which he calls *Prodryas Persiphone*, is wonderfully perfect, the wings expanded as if in readiness for the cabinet, and even the form of the scales are distinguishable under the microscope.

IV. ASTRONOMY.

1. *Observations of Comets made at the Sheffield Observatory of Yale College;* by H. A. HAZEN and W. BEEBE, with the ring micrometer of the $8\frac{3}{4}$ inch refractor. (Latitude of observatory= 41° 18′ 35″; longitude=16^m $30^s{\cdot}0$ E. of Washington.)—All the observations upon which the following results are based were made with a power of 60. The ring-micrometer is one constructed by Professor Lyman, and consists of several concentric rings. Of these, only the two smallest were used; and of the two, one or the other was sometimes omitted, if observation was thereby facilitated. A complete transit across one ring, comprising two ingresses and two egresses of each body, is considered as one comparison. In estimating the weights, an observation derived from six comparisons under fair conditions is assigned a weight of 2. This does not take into account, in case of comet *c*, the liability to error, arising from the fact that the comet exhibited no defined nucleus, nor has it any reference to the reliability of the catalogue from which a star's place is derived.

Comet b, 1877, (Winnickey.)

1877. New Haven m. t.	Comet—s. Δα	Comet—s. Δδ	Apparent α	log. Par. × Δ	Apparent δ	log. Par. × Δ	Comp. Star.	No. of Comparisons.	Weight of obs.
h m s	m s		h m s						
May 3, 9 59 48·	+3 8·53	+10′ 27·″3	23 19 2·23	·7581n	+64° 14′ 35·″0	·9080	a	4	1
" 4, 8 53 22·	−3 52·19	+ 6 18·6	23 26 24·82	·1350n	66 17 5·3	·9254	r	8	2
" 24, 13 44 17·	−1 46·26	+ 2 29·5	8 13 0·49	1·0109	68 37 6·4	·8601	b	11	2
" " 14 42 20·	−1 27·78	+ 0 34·3	8 13 19·97	·7891	68 35 11·2	·9006	b	4	1
" 28, 8 58 17·	−2 25·70	− 4 3·2	8 36 7·77	1·1550	63 42 32·4	9·8857	c	8	2
" " 10 15 8·	−2 11·20	− 7 56·7	8 36 22·27	1·1751	63 38 38·9	·4399	c	7	2
" 29, 8 55 24·	−2 36·20	+ 5 41·6	8 40 38·61	1·1352	62 31 7·0	9·9116	d	9	3
June 1, 10 26 48·	−0 26·42	+ 4 45·9	8 51 52·49	1·1105	59 5 0·6	·5367	e	12	3
" 2, 10 41 59·	+0 23·46	+11 55·0	8 54 56·23	1·0949	58 1 14·3	·6985	f	9	3
" 8, 9 24 59·	+0 57·45	− 6 1·3					g	12	3
" 14, 9 32 35·	−1 49·40	− 1 23·6	9 19 1·67	·9939	47 42 26·0	·5621	h	6	1
" " 10 4 44·	−1 47·44	− 2 28·8	9 19 3·63	·9930	47 41 20·2	·6378	h	8	1
" 16, 10 22 2·	+1 14·32	+ 8 43·9	9 21 42·80	·9759	46 17 15·8	·6901	i	11	2
" " 11 34 1·	−3 17·29	+11 53·9	9 21 54·71	·9265	46 15 27·2	·8016	k	9	2
" 20, 9 46 50·	+1 41·29	− 5 47·5	9 26 51·55	·9564	43 45 30·8	·7042	l	8	1
" " 10 11 36·	+1 42·03	− 6 24·2	9 26 52·29	·9464	43 44 55·1	·7396	l	8	2
" 22, 10 56 35·	−2 46·32	− 4 10·4	9 29 12·20	·9184	42 33 8·2	·6840	m	8	2
" 29, 9 29 0·	+1 32·90	+ 0 5·7	9 36 21·31	·9288	38 54 58·9	·6999	n	12	2
July 4, 9 31 9·	−2 1·84	+11 41·6	9 40 58·46	·9105	36 38 32·4	·7344	o	7	1
" " 10 7 46·	−2 0·91	+10 56·7	9 40 59·39	·8868	36 37 51·5	·7829	o	8	½
" 12, 9 29 38·	−3 16·09	+ 7 56·0	9 47 42·04	·8272	33 29 7·3	·8353	p	8	1

Mean place of comparison stars for 1877·0, with reductions to date of observations.

		α	δ
	h m s	h m s s	° ′ ″ ″
a=Oeltz. Arg. N.Z.	(a 1842, 23 14 26·69)	23 15 55·60 − 1·90	64 4 17·0 − 9·3
b=Fedorenko	(a 1790, 8 6 7·32)	8 14 45·92 + 1·83	68 34 21·4 + 15·6
c=Rümker	2631,	8 38 31·58 + 1·89	63 46 21·8 + 13·8
d=Groombridge	1472,	8 43 12·92 + 1·89	62 25 12·0 + 13·4
e=Oeltz. Arg. N.Z.	(a 1842, 8 49 32·20)	8 52 17·07 + 1·84	59 0 2·6 + 12·1
f= " "	(a 1842, 8 51 50·19)	8 54 30·97 + 1·80	57 49 7·5 + 11·[illegible]
h= " "	(a 1842, 9 18 28·56)	9 20 49·32 + 1·75	47 43 38·9 + 10·[illegible]

	h m s	α h m s s	δ ° ′ ″ ″
i = Washington 26 year cat.	39·50	9 20 35·86 + 1·63	46 8 24·6 + 7·3
k = Radcliffe	2357,	9 25 10·35 + 1·62	46 3 26·1 + 7·2
l = Lalande	18693,	9 25 8·68 + 1·58	43 51 13·1 + 6·2
m = Weisse (2) IX	644,	9 31 56·94 + 1·58	42 37 12·7 + 5·9
n = " "	707,	9 34 46·89 + 1·52	38 54 49·9 + 3·3
o = Lalande	19244,	9 42 58·80 + 1·50	36 26 48·6 + 3·2
p = Weisse (2) IX	1053, Lal. 19469	9 50 56·64 + 1·49	33 37 2·3 + 1·0
			assumed $\frac{L+2W}{3}$

s = Bonn obs. I. zone 52 1376, position only approximate.
r = Rümker 11396, 23 30 18·91 − 1·91 66 10 56·0 + 9·3

Comet c, 1877, (*Swift.*)

1877. New Haven m. t.	Comet—s. Δα	Comet—s. Δδ	Apparent α	log. Par. × Δ	Apparent δ	log. Par. × Δ	Comp. Star.	No. of Comparisons.	Weight of obs.
h m s	m s		h m s						
Apr. 12, 9 2	−9 4·4	− 8′ 48·″	0 53 23·4	·7986	+53°56′ 5·″	.8901	a	3	1
" 22, 16 1 5·	+3 10·39	−16 55·2	2 29 23·90	·7304	60 16 57·0	·8129	b	5	2
May 2, 10 30 31·	+2 44·32	+10 23·2					c	6	2
" 3, 8 34 48·	−2 39·92	+15 48·0	4 49 48·56	1·1243	60 31 39·3	·5501	d	7	2
" 4, 9 47 2·	−3 18·43	− 0 10·0	5 3 11·63	1·0848	60 2 56·9	·7211	e	11	3
" 6, 13 54 32·	−6 40·	+ 4 32·	5 29 42·30	·2818	58 48 38·9	·9368	f	8	2
" 12, 12 15 24·	−3 2·9	−10 47·	6 30 10·60	·8858	54 3 5·6	·8979	g	8	2
June 1, 9 36 9·	−0 25·90	− 3 6·4	8 19 57·12	·9134	33 53 6·6	·6851	h	6	1
" 1, 9 36 9·	−0 34·59	−12 38·5	8 20 0·17	·9134	33 52 54·5	·6851	i	6	1
" 2, 9 57 57·	+1 53·55	−13 44·3	8 23 23·99	·8969	32 52 18·5	·7160	k	4	1

Place of comparison stars.

	α h m s s	δ ° ′ ″ ″
a = Lalande 2000,	1 2 28·33 − 1·53	54 4 50·6 + 2·6
b = Bonn obs., vol. vi,	2 26 15·09 − 1·58	60 34 0·8 + 8·6
c = " " " v, zone 60, No. 834, position only approximate.		
d = Wash. 26 year cat. 2107, Rümker 1332,	4 52 28·86 − ·28	60 15 35·9 + 15·4 assumed $\frac{R+2W}{3}$
e = Lalande 9739	5 6 30·19 − ·13	60 2 51·5 + 15·4
f = " 10687	5 36 22·10 + ·20	58 43 50·9 + 16·0
g = Bonn obs., vol. vi, p. 268	6 33 12·72 + ·78	54 13 37·6 + 15·0
h = Lalande 16548–9	8 20 21·76 + 1·26	33 56 5·9 + 7·1
i = " 16557	8 20 33·52 + 1·24	34 5 25·8 + 7·2
k = " 16592	8 21 29·20 + 1·24	33 5 56·0 + 6·8

Comet e, 1877, (*Coggia.*)

1877. New Haven m. t.	Comet—s. $\Delta\alpha$	Comet—s. $\Delta\delta$	Apparent α	log. Par. × Δ	Apparent δ	log. Par. × Δ	Comp. Star.	No. of Comparisons.	Weight of obs.
h m s	m s		h m s						
Oct. 2, 13 38 2·	+2 33·60	+25′ 21·″6	8 19 1·59	·9569*n*	+42° 49′ 8·″6	·6170	*a*	3	1

Place of comparison stars.

	α h m s s	δ ° ′ ″ ″
a=Wash. 26 year cat. 3370	8 16 22·77 +5·22	42 23 56·0 − 9·0

Comet f, 1877, (*Tempel.*)

1877. New Haven m. t.	Comet—s. $\Delta\alpha$	Comet—s. $\Delta\delta$	Apparent α	log. Par. × Δ	Apparent δ	log. Par. × Δ	Comp. Star.	No. of Comparisons.	Weight of obs.
h m s	m s		h m s						
Oct. 5, 10 30 40·	+1 12·94	+ 2′ 10·″8	23 39 6·38	9·3727*n*	−13° 49′ 43·3	·8608	*a*	11	3
" 6, 9 23 30·	+2 16·94	+ 6 41·2	23 36 45·36	9·6396*n*	−14 47 1·5	·8656	*b*	11	3
" 7, 9 48 24·	+4 5·86	+14 35·7	23 32 34·92	·0430*n*	−15 40 22·3	·8689	*c*	12	3
" 9, 9 25 16·	−2 34·80	− 5 6·8	23 26 32·66	9·6305	−17 20 25·0	·8280	*d*	8	2
" 11, 7 41 24·	+2 21·98	− 2 35·2	23 21 11·19	·5967*n*	−18 48 30·6	·8897	*e*	6	2
" 12, 10 18 19·	+0 36·32	−13 16·4	23 15 8·93	9·9682	−19 25 53·3	·8764	*f*	6	1

a=Weisse XXIII 744	23 37 49·23 +4·21	−13 52 17·8 +23·7
b=Oeltz. Argel. L. 22963	23 33 24·19 +4·23	−14 54 5·9 +23·2
c=Rümker 11352	23 28 24·82 +4·24	−15 55 20·6 +22·6
d=Lalande 46199	23 29 3·21 +4·25	−17 15 40·4 +22·2
e= " 45838	23 18 44·95 +4·26	−18 46 16·3 +21·0
f= " 45704	23 14 28·38 +4·28	−19 12 57·4 +20·5

V. Miscellaneous Scientific Intelligence.

1. *Japanese Earthquakes.*—An interesting historical paper upon "Destructive Earthquakes in Japan," (27 pp.) was read before the Asiatic Society of Japan, March 23d, 1878, by I. Z. Hattori, Esq. (Rutgers Coll.), of the University of Tokio.

It includes notices, drawn from native sources, of 149 destructive earthquakes, distributed as follows:

1 in 5th century.		7 in 13th century.	
1 " 6th	"	8 " 14th	"
7 " 7th	"	15 " 15th	"
7 " 8th	"	8 " 16th	"
28 " 9th	"	15 " 17th	"
11 " 10th	"	13 " 18th	"
10 " 11th	"	16 " 19th	"
1 " 12th	"		

Arranging the recorded shocks according to the seasons the author says: "If we take the 11th, 12th, and 1st months of the Japanese old calendar as cold months, 5th, 6th and 7th as hot, and all the others as mild, then during the fifteen centuries, twenty-eight great earthquakes have occurred in the cold months, forty-seven in the hot, and seventy-two in the mild, or in other words, seventy-five in the extreme seasons and seventy-two in the mild, the difference being only three." He also gives a curious description of an early Chinese seismograph "invented by Choko in the first year of Yoka, (132 A. D.)" It is quoted from the Life of Choko in Gokwanjo (History of Kwan), and is as follows.

"The seismograph consisted of a copper vessel, whose diameter was eight *shaker* or feet, and whose convex cover was ornamented with characters, mountain turtles, birds and beasts. In this vessel there was one main piston in the middle with its eight branches, wires and springs. On the outside of this vessel were eight dragon heads, each of them having a copper ball in its full-opened mouth. Under each of the dragon heads there was a frog looking upwards with its mouth fully opened. The wire works and springs were very skillfully arranged in the vessel, but the cover was very closely fitted, and they could not be seen. Whenever the earth shook, one of the dragons dropped the ball, the frog underneath received it in its mouth, and produced a sound. By this means the direction of the shocks was ascertained. Once one of the dragons dropped its ball, but no person near it perceived any shock, and all the learned men of the capital doubted the trustworthiness of the machine; but after a few days a mail arrived from Rosei and reported the occurrence of an earthquake there."

The different Japanese beliefs or superstitions about the cause of earthquakes are also described. C. G. R.

2. *American Association at St. Louis, Aug.* 21.—The headquarters of the Association at St. Louis will be at the Lindell Hotel on the Monday and Tuesday preceding the meeting, and afterward at Armory Hall. All members planning to attend the meeting are requested to communicate at once with Prof. J. K. Rees, who is Secretary of the Local Committee. Communications relative to membership, papers, and payments of assessments should be made to the Permanent Secretary, F. W. Putnam, whose address is Salem, Mass., until Wednesday, Aug. 14, and after that time, St. Louis, Missouri. The first meeting of the Standing Committee will be at the Lindell Hotel, on Wednesday, Aug. 20, at 3 P. M.

Arrangements for half fare on various railroads can be learned of by addressing Wm. Taussig, St. Louis.

3. *Catalogue of Scientific Serial Publications.*—An extended catalogue of Scientific Serials is soon to be issued under the auspices of the Librarian of Harvard College. It has been prepared by Mr. Samuel H. Scudder, Librarian of the American Academy of Arts and Sciences. The work has double the extent of any existing list of the kind, and aims to include all Society Transactions and independent journals in every branch of natural, mathematical and physical science, excepting only the applied sciences, medicine, agriculture, technology, etc. The arrangement is based on the countries and places where published. It will be a work of great value to all libraries and men of science. The volume will be in octavo, and extend to about 300 pages. Those desiring the work should address Justin Winsor, Librarian of Harvard College, Cambridge, Mass.

4. *Principles of Machine Construction: an application of geometrical drawing for the representation of Machinery*; by EDWARD TOMKINS, edited by HENRY EVERS, LL.D. Vol. i, Text, 368 pp. 8vo; vol. ii, Plates, small quarto. New York, 1878. (G. P. Putnam's Sons—Putnam's Advance Science Series.)—A clearly written and well arranged treatise, rendered the more useful by the numerous illustrations in the text, and still more by the forty-seven excellent plates.

5. *Geological Survey of Victoria.*—Decade 5 of the Paleontology of Victoria, by FREDERICK MCCOY, has appeared. Among the Victorian species mentioned is the graptolite, *Didymograptus Headi*, described by Hall from the Lower Silurian of Canada.

6. *On the Paleozoic fossils of New South Wales*; by L. G. DE KONINCK. 374 pp. 8vo, with an Atlas of 24 quarto plates.—This work is a complete review of the facts relating to the Paleozoic fossils of New South Wales, and contains descriptions of 176 species. Besides this, it enumerates 76 species described by others, of which the writer had not yet seen specimens. Out of the 176, 74 exist also in European rocks.

7. *Mineralogische und petrographische Mittheilungen, herausgegeben* von G. TSCHERMAK; Neue Folge, Bd. I, Heft 1. Vienna, 1878.—The *Mineralogische Mittheilungen* of Vienna, begun by Professor Tschermak in 1872 and published as a supplement to the Jahrbuch of the k. k. Geologische Reichsanstalt have been discontinued. In its place, the Journal, whose title is given above, is to appear independently, in six numbers each year. The new "Mittheilungen" are to be still under the able editorship of Professor Tschermak, and will doubtless take even a more important place among the publications in this branch than the earlier journal. The first number contains five excellent articles upon various mineralogical and lithological subjects.

8. *Marine Zoological Laboratories for instruction of Students.*—A marine laboratory for zoological instruction is to be opened at Fort Wool, on the Rip Raps, near Fortress Monroe, near the

mouth of Chesapeake Bay, under the auspices of the Johns Hopkins University, and the charge of Professor Brooks; and another on Salem Neck, between Beverly and Salem Harbor, Massachusetts, by J. H. Emerton and C. S. Minot, between June 1 and October 1, with the terms $20.00 a month.

9. *Microscopical Society of San Francisco.*—A bulletin from this Society announces that the secretary, Mr. Clarke, will exchange specimens from the diatom deposits of the Pacific Coast on receipt of "any valuable microscopic material."

10. *Earthquake of the South American Coast felt at the Russian Observatory at Pulkowa.*—In a communication to the Academy of Sciences, St. Petersburg, Mr. Magnus Nyrén of the observatory at Pulkowa states that the great earthquake on the coast of South America, in May of last year, was perceptible at Pulkowa by a tremor of the instrument with which he was observing the passage of a star; that the tremor continued sufficiently long to be satisfactorily verified, and that there was no disturbance in the neighborhood by which it could have been occasioned. —*Athenæum*, May 25*th*.

11. *Probable Distribution of a Spider by the Trade Winds.*—Rev. H. C. McCook states that the *Sarotes venatorius* Linn., a large laterigrade spider of the ballooning kind, occurs, according to specimens in his private collection, from Santa Cruz, Virgin Isles, to Cuba, Florida and Yucatan, Central America, Mexico and California, Sandwich Islands, Loochoo Islands and Japan, and thence across Asia and Africa to Liberia, and suggests, in view of these facts and other localities on record, that the trade winds have promoted this distribution. Among the other localities, are the Society Islands, Feejees, Friendly Islands, New Caledonia, Eastern Australia, Mauritius, Madagascar, and several parts of South America. He refers to a fact stated by Darwin, that, at a distance of sixty miles from land, while the Beagle was sailing before a steady light breeze, the rigging was covered with vast numbers of small spiders with their webs, each, when first coming in contact with the rigging, seated upon a single filament of spider web, and so slenderly in some cases that a single breath of air was found to bear them out of sight. Mr. McCook states that the specimens examined by him show *no variations* which may not be accounted for "by differences in age, or which may not come within those ordinary natural differences which all animals more or less exhibit." But most of the specimens had lost their colors in the alcohol in which they were preserved.—*Proc. Acad. Nat. Sci. Philad.*, 1878, p. 136.

12. *Polymicroscope.*—A new improvement in the microscope is reported from Germany. Herr I. von Lenhossék has constructed an apparatus which permits no less than sixty microscopical preparations being observed in immediate succession, without the trouble of changing the slides and readjustment of the object-glass. Its construction is similar in principle to that of the well-known revolving stereoscopes, and the inventor has given the new apparatus the name of "polymicroscope."—*Nature*, June 6.

13. *The Telephone for Deaf Persons.*—Having seen a paragraph in Nature communicated by Mr. Severn, of Newcastle, New South Wales, describing a method of using a telephone to enable deaf persons to hear, I have tried the experiment in the manner Mr. Severn describes—by fastening a string to the parchment diaphragm of a simple telephone made of wood, and carrying this string round the forehead of the deaf person, who clasps the string with both hands and presses them over his ears. The experiment in this way was partially successful; the sound of the voice was always heard, and some words were distinguished. Afterwards I fastened a single string to the telephone and got the deaf person to hold the string between his teeth. He then heard every word distinctly, even when spoken in a low tone of voice at the whole length of the room.—*John Browning, in Nature of June* 13.

New works in Science, notices of which are unavoidably deferred.

Report on Astronomy and Barometric Hypsometry, making vol. II, of quarto Reports of the U. S. Geographical Survey West of the 100th Meridian, under Lieut. G. M. Wheeler. 566 pp. 4to, with 22 plates.

Pennsylvania Geological Survey. Report of Progress in the Beaver River District of the Bituminous Coal-fields of Western Pennsylvania: by J. C. White. 338 pp. 8vo, with 12 plates. Harrisburg. 1878.

Mineralogy and Lithology of New Hampshire, by G. W. Hawes, Geological Survey of New Hampshire. 262 pp. roy. 8vo. With 12 plates. Concord, N. H. 1878.

Report on Food-fishes, Fish-culture for 1875–1876. By S. F. Baird. 1030 pp. 8vo. U. S. Commission of Fish and Fisheries. Washington. 1878.

Report on Geological Survey of Canada, for 1876–77. A. R. C. Selwyn, Director. 532 pp. 8vo. 1878.

Report on Forrestry, prepared under direction of the Commissioner of Agriculture. By F. B. Hough. 650 pp. 8vo. Washington. 1878.

The Speaking Telephone, Talking Phonograph and other Novelties, by G. B. Prescott. 432 pp. 8vo, with many illustrations. New York. 1878. (D. Appleton & Co.)

Annual Record of Science and Industry for 1877, edited by Spencer F. Baird, with the assistance of men of science. 480 pp. New York. 1878. (Harper & Brothers.)

Elements of Dynamic; an Introduction to the Study of Motion and Rest in Solid and Fluid Bodies, by W. K. Clifford, F.R.S. Part I, Kinematic. 222 pp. 12mo. London. 1878. (Macmillan & Co.)

Die Vereinigten Staaten von Nord America, von Dr. Friedr. Ratzel, Professor der Erdkunde zu München. Erster Band, Physikalische Geographie und Naturcharakter. 668 pp. large 8vo, with illustrations. Munich. 1878.

Metasomatic Development of the Copper-bearing Rocks of Lake Superior, by R. Pumpelly. 310 pp. 8vo. Proc. Am. Acad., vol. xiii.

Bulletin of the Bussey Institution of Harvard University. Vol. ii, Part iii. Boston. 1878.

Tafeln zur Bestimmung der Mineralien von Franz von Kobell. Elfte vermehrte Auflage. 110 pp. 8vo. München. 1878.

Notes from the Chemical Laboratory of the Johns Hopkins University. Nos. 9–12. Baltimore, Md.

Report on the Hydroida collected during the Exploration of the Gulf Stream by L. F. de Pourtalès, Assistant U. S. Coast Survey and forming No. 2 of vol. v of the Memoirs of the Museum of Comparative Zoology at Harvard College, by G. J. Allman. 64 pp. 4to, with 34 plates. Cambridge, Mass. 1877.

BAROMETRIC FLUCTUATIONS.

PLATE I

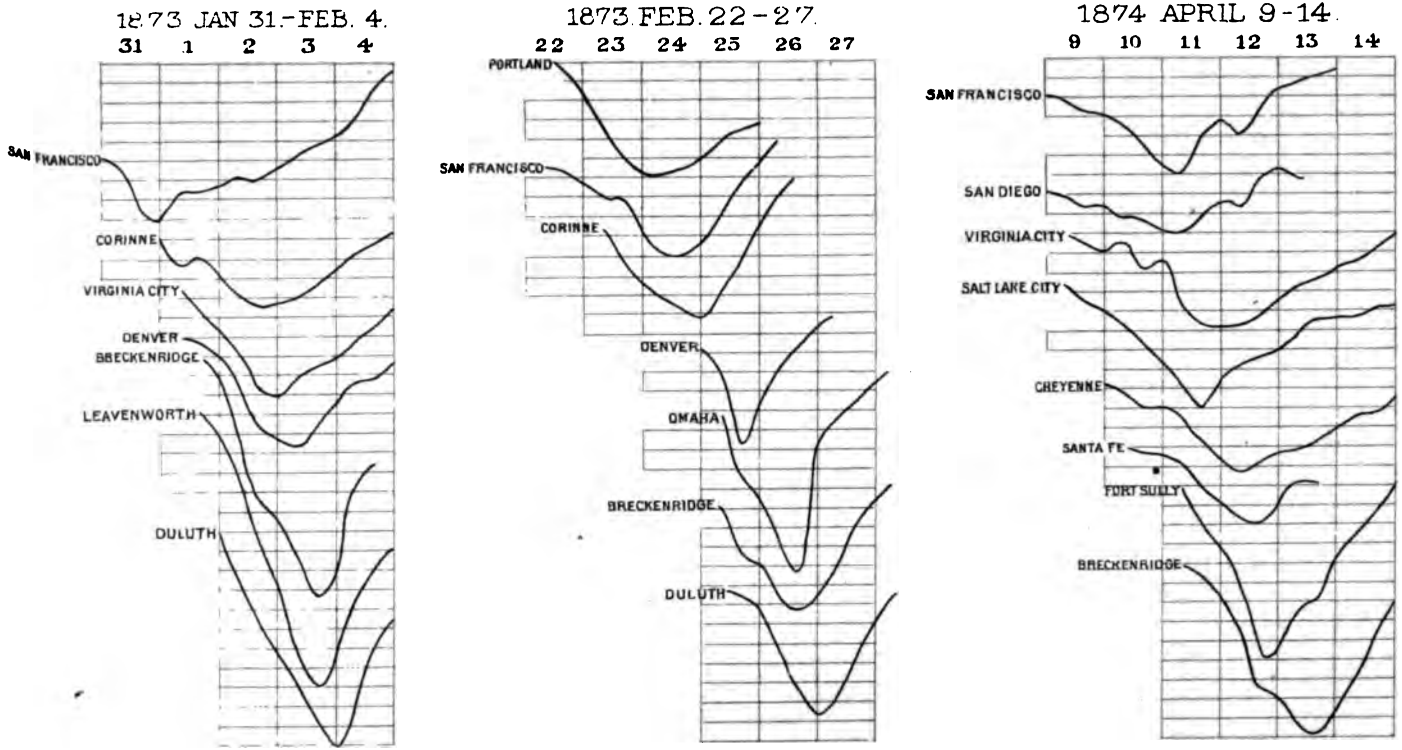
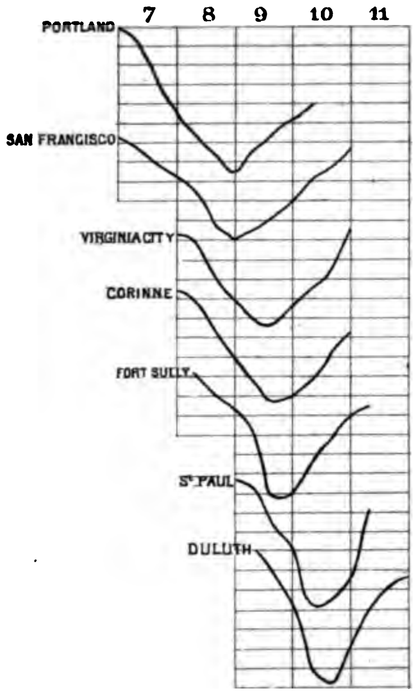
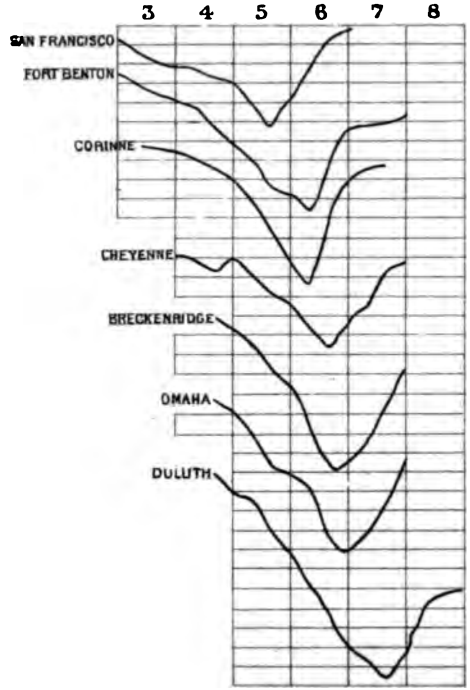
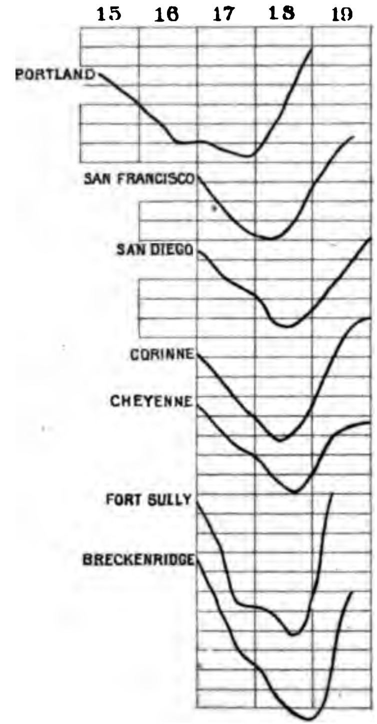


PLATE II.

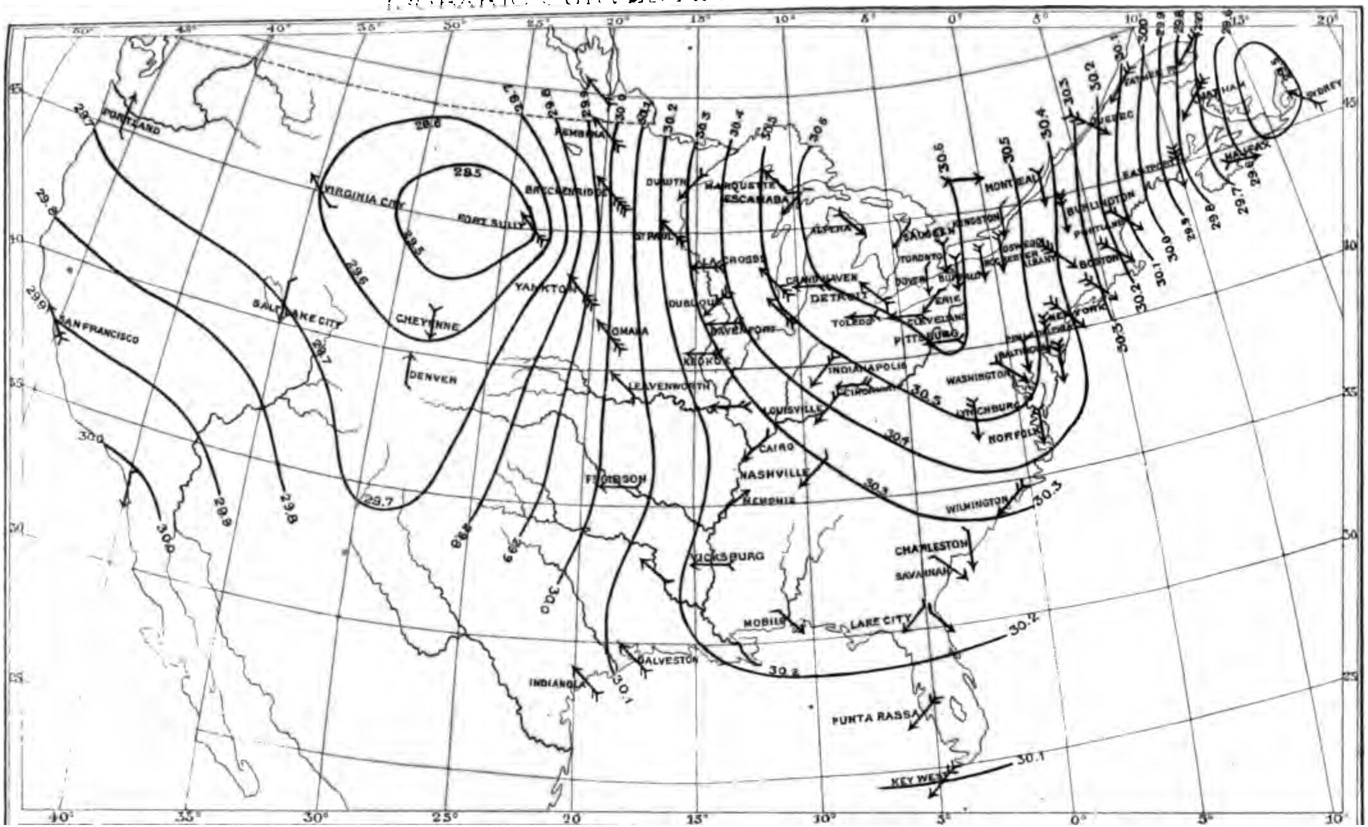
BAROMETRIC FLUCTUATIONS.







ISOBARIC CURVES APRIL 12. 1874. 7.35 A.M PLATE III



THE

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JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. IX.—*Forest Geography and Archæology: a Lecture delivered before the Harvard University Natural History Society*, April 18, 1878; by ASA GRAY.

. . . . IT is the forests of the Northern temperate zone which we are to traverse. After taking some note of them in their present condition and relations, we may enquire into their pedigree; and, from a consideration of what and where the component trees have been in days of old, derive some probable explanation of peculiarities which otherwise seem inexplicable and strange.

In speaking of our forests in their present condition, I mean not exactly as they are to-day, but as they were before civilized man had materially interfered with them. In the district we inhabit such interference is so recent that we have little difficulty in conceiving the conditions which here prevailed, a few generations ago, when the "forest primeval"—described in the first lines of a familiar poem—covered essentially the whole country, from the Gulf of St. Lawrence and Canada to Florida and Texas, from the Atlantic to beyond the Mississippi. This, our Atlantic forest, is one of the largest and almost the richest of the temperate forests of the world. That is, it comprises a greater diversity of species than any other, except one.

In crossing the country from the Atlantic westward, we leave this forest behind us when we pass the western borders of those organized States which lie along the right bank of the Mississippi. We exchange it for prairies and open plains, wooded only along the water-courses,—plains which grow more

and more bare and less green as we proceed westward, with only some scattering cottonwoods (i. e. poplars) on the immediate banks of the traversing rivers, which are themselves far between.

In the Rocky Mountains we come again to forest, but only in narrow lines or patches; and if you travel by the Pacific Railroad you hardly come to any; the eastern and the interior-desert plains meet along the comparatively low level of the divide which here is so opportune for the railway; but both north and south of this line the mountains themselves are fairly wooded. Beyond, through all the wide interior basin, and also north and south of it, the numerous mountain chains seem to be as bare as the alkaline plains they traverse, mostly north and south; and the plains bear nothing taller than sage-brush. But those who reach and climb these mountains find that their ravines and higher recesses nourish no small amount of timber, though the trees themselves are mostly small and always low.

When the western rim of this great basin is reached there is an abrupt change of scene. This rim is formed of the Sierra Nevada. Even its eastern slopes are forest-clad in great measure; while the western bear in some respects the noblest and most remarkable forest of the world;—remarkable even for the number of species of evergreen trees occupying a comparatively narrow area, but especially for their wonderful development in size and altitude. Whatever may be claimed for individual Eucalyptus-trees in certain sheltered ravines of the southern part of Australia, it is probable that there is no forest to be compared for grandeur with that which stretches, essentially unbroken,—though often narrowed, and nowhere very wide,—from the southern part of the Sierra Nevada in lat. 36° to Puget Sound beyond lat. 49°, and not a little farther.

Descending into the long valley of California, the forest changes, dwindles, and mainly disappears. In the Pacific Coast Ranges, it resumes its sway, with altered features, some of them not less magnificent and of greater beauty. The Redwoods of the coast, for instance, are little less gigantic than the Big-trees of the Sierra Nevada, and far handsomer, and a thousand times more numerous. And several species which are merely or mainly shrubs in the drier Sierra, become lordly trees in the moister air of the northerly coast ranges. Through most of California these two Pacific forests are separate; in the northern part of that State they join, and form one rich woodland belt, skirting the Pacific, backed by the Cascade Mountains, and extending through British Columbia into our Alaskan territory.

So we have two forest-regions in North America,—an Atlan-

tic and a Pacific. They may take these names, for they are dependent upon the oceans which they respectively border. Also we have an intermediate isolated region or isolated lines of forest, flanked on both sides by bare and arid plains,—plains which on the eastern side may partly be called *prairies*,—on the western, *deserts*.

This mid-region mountain forest is intersected by a transverse belt of arid and alkaline plateau, or eastward of grassy plain—a hundred miles wide from north to south,—through which passes the Union Pacific Railroad. This divides the Rocky-mountain forest into a southern and a northern portion. The southern is completely isolated. The northern, in a cooler and less arid region, is larger, broader, more diffused. Trending westward, on and beyond the northern boundary of the United States, it approaches, and here and there unites with, the Pacific forest. Eastward, in Northern British territory, it makes a narrow junction with northwestward prolongations of the broad Atlantic forest.

So much for these forests as a whole, their position, their limits. Before we glance at their distinguishing features and component trees, I should here answer the question, why they occupy the positions they do;—why so curtailed and separated at the south, so much more diffused at the north, but still so strongly divided into eastern and western. Yet I must not consume time with the rudiments of physical geography and meteorology. It goes without saying that trees are nourished by moisture. They starve with dryness and they starve with cold. A tree is a sensitive thing. With its great spread of foliage, its vast amount of surface which it cannot diminish or change, except by losing that whereby it lives, it is completely and helplessly exposed to every atmospheric change; or at least its resources for adaptation are very limited; and it cannot flee for shelter. But trees are social, and their gregarious habits give a certain mutual support. A tree by itself is doomed, where a forest, once established, is comparatively secure.

Trees vary as widely as do other plants in their constitution; but none can withstand a certain amount of cold and other exposure, nor make head against a certain shortness of summer. Our high northern regions are therefore treeless; and so are the summits of high mountains in lower latitudes. As we ascend them we walk at first under spruces and fir-trees or birches; at 6,000 feet on the White Mountains of New Hampshire, at 11 or 12,000 feet on the Colorado Rocky Mountains, we walk through or upon them; sometimes upon dwarfed and depressed individuals of the same species that made the canopy below. These depressed trees retain their hold on life

only in virtue of being covered all winter by snow. At still higher altitude the species are wholly different; and for the most part these humble alpine plants of our temperate zone—which we cannot call trees, because they are only a foot or two or a span or two high—are the same as those of the arctic zone, of northern Labrador, and of Greenland. The arctic and the alpine regions are equally unwooded from cold.

As the opposite extreme, under opposite conditions, look to equatorial America, on the Atlantic side, for the widest and most luxuriant forest-tract in the world, where winter is unknown, and a shower of rain falls almost every afternoon. The size of the Amazon and Orinoco—brimming throughout the year—testifies to the abundance of rain and its equable distribution.

The other side of the Andes, mostly farther south, shows the absolute contrast, in the want of rain, and absence of forest; happily it is a narrow tract. The same is true of great tracts either side of the equatorial regions, the only district where great deserts reach the ocean.

It is also true of great continental interiors out of the equatorial belt, except where cloud-compelling mountain-chains coerce a certain deposition of moisture from air which could give none to the heated plains below. So the broad interior of our country is forestless from dryness in our latitude, as the high northern zone is forestless from cold.

Regions with distributed rain are naturally forest-clad. Regions with scanty rain, and at one season, are forestless or sparsely wooded, except they have some favoring compensations. Rainless regions are desert.

The Atlantic United States in the zone of variable weather and distributed rains, and the Gulf of Mexico as a caldron for brewing rain, and no continental expanse between that great caldron and the Pacific, crossed by a prevalent southwest wind in summer, is greatly favored for summer as well as winter rain.

And so this forest region of ours, with annual rain-fall of fifty inches on the Lower Mississippi, fifty-two inches in all the country east of it bordering the Gulf of Mexico, forty-five to forty-one in all the proper Atlantic district from East Florida to Maine, and the whole region drained by the Ohio,—diminished only to thirty-four inches on the whole Upper Mississippi and Great Lake region,—with this amount of rain, fairly distributed over the year, and the greater part not in the winter, our forest is well accounted for.

The narrow district occupied by the Pacific forest has a much more unequal rainfall, more unequal in its different parts, most unequal in the different seasons of the year, very different in the same place in different years.

From the Gulf of Mexico to the Gulf of St. Lawrence, the amount of rain decreases moderately and rather regularly from south to north; but, as less is needed in a cold climate, there is enough to nourish forest throughout. On the Pacific coast, from the Gulf of California to Puget Sound, the southerly third has almost no rain at all; the middle portion less than our Atlantic least; the northern third has about our Atlantic average.

Then, New England has about the same amount of rain-fall in winter and in summer; Florida and Alabama about one-half more in the three summer than in the three winter months,—a fairly equable distribution. But on the Pacific coast there is no summer rain at all, except in the northern portion, and there little. And the winter rain, of forty-four inches on the northern border, diminishes to less than one-half before reaching the Bay of San Francisco; dwindles to twelve, ten, and eight inches on the southern coast, and to four inches before we reach the United States boundary below San Diego.

Taking the whole year together, and confining ourselves to the coast, the average rain-fall for the year, from Puget Sound to the border of California, is from eighty inches at the north to seventy at the south, i. e., seventy on the northern edge of California: thence it diminishes rapidly to thirty-six, twenty (about San Francisco), twelve, and at San Diego to eight inches.

The two rainiest regions of the United States are the Pacific coast north of latitude forty-five, and the northeastern coast and borders of the Gulf of Mexico. But when one is rainy the other is comparatively rainless. For while this Pacific rainy region has only from twelve to two inches of its rain in the summer months, Florida, out of its forty to sixty, has twenty to twenty-six in summer, and only six to ten of it in the winter months.

Again, the diminution of rain-fall as we proceed inland from the Atlantic and Gulf shores, is gradual; the expanse that is or was forest-clad is very broad, and we wonder only that it did not extend farther west than it does.

On the other side of the continent, at the north, the district so favored with winter rain is but a narrow strip, between the ocean and the Cascade Mountains. East of the latter, the amount abruptly declines,—for the year from eighty inches to sixteen; for the winter months, from forty-four and forty to eight and four inches; for the summer months, from twelve and four to two and one.

So we can understand why the Cascade Mountains abruptly separate dense and tall forest on the west from treelessness on the east. We may conjecture, also, why this North Pacific forest is so magnificent in its devolopment.

Equally, in the rapid decrease of rain-fall southward, in its corresponding restriction to one season, in the continuation of the Cascade Mountains as the Sierra Nevada, cutting off access of rain to the interior, in the unbroken stretch of coast ranges near the sea, and the consequent small and precarious rain-fall in the great interior valley of California, we see reasons why the Californian forest is mainly attenuated southward into two lines,—into two files of a narrow but lordly procession, advancing southward along the coast ranges, and along the western flank of the Sierra Nevada, leaving the long valley between comparatively bare of trees.

By the limited and precarious rain-fall of California, we may account for the limitations of its forest. But how shall we account for the fact that this district of comparatively little rain produces the largest trees in the world? Not only produces, alone of all the world, those two peculiar *big trees* which excite our special wonder,—their extraordinary growth might be some idiosyncracy of a race,—but also produces pines and fir-trees, whose brethren we know, and whose capabilities we can estimate, upon a scale only less gigantic. Evidently there is something here wonderfully favorable to the development of trees, especially of coniferous trees; and it is not easy to determine what it can be.

Nor, indeed, does the rain-fall of the coast of Oregon, great as it is, fully account for the extraordinary development of its forest; for the rain is nearly all in the winter, very little in summer. Yet here is more timber to the acre than in any other part of North America, or perhaps in any other part of the world. The trees are never so enormous in girth as some of the Californian, but are of equal height—at least on the average—three hundred feet being common, and they stand almost within arms' length of each other.

The explanation of all this may mainly be found in the great climatic differences between the Pacific and the Atlantic sides of the continent; and the explanation of these differences is found in the difference in the winds and the great ocean currents.

The winds are from the ocean to the land all the year round, from northwesterly in summer, southwesterly in winter. And the great Pacific Gulf-stream sweeps toward and along the coast, instead of bearing away from it, as on our Atlantic side.

The winters are mild and short, and are to a great extent a season of growth, instead of suspension of growth as with us. So there is a far longer season available to tree-vegetation than with us, during all of which trees may either grow or accumulate the materials for growth. On our side of the continent and in this latitude, trees use the whole autumn in getting ready for a six-months winter, which is completely lost time.

Finally, as concerns the west coast, the lack of summer rain is made up by the moisture-laden ocean winds, which regularly every summer afternoon wrap the coast-ranges of mountains, which these forests affect, with mist and fog. The Redwood, one of the two California big trees,—the handsomest and far the most abundant and useful,—is restricted to these coast-ranges, bathed with soft showers fresh from the ocean all winter, and with fogs and moist ocean air all summer. It is nowhere found beyond the reach of these fogs. South of Monterey, where this summer condensation lessens, and winter rains become precarious, the Redwoods disappear, and the general forest becomes restricted to favorable stations on mountain sides and summits. . . . . . The whole coast is bordered by a line of mountains, which condense the moisture of the sea-breezes upon their cool slopes and summits. These winds, continuing eastward, descend dry into the valleys, and warming as they descend, take up moisture instead of dropping any. These valleys, when broad, are sparsely wooded or woodless, except at the north, where summer-rain is not very rare.

Beyond stretches the Sierra Nevada, all rainless in summer, except local hail-storms and snow-falls on its higher crests and peaks. Yet its flanks are forest-clad; and, between the levels of 3,000 and 9,000 feet, they bear an ample growth of the largest coniferous trees known. In favored spots of this forest—and only there—are found those groves of the giant *Sequoia*, near kin of the Redwood of the coast-ranges, whose trunks are from fifty to ninety feet in circumference, and height from two hundred to three hundred and twenty-five feet. And in reaching these wondrous trees you ride through miles of sugar-pines, yellow pines, spruces and firs, of such magnificence in girth and height, that the big trees, when reached—astonishing as they are—seem not out of keeping with their surroundings.

I cannot pretend to account for the extreme magnificence of this sierra-forest. Its rain-fall is in winter, and of unknown but large amount. Doubtless most of it is in snow, of which fifty or sixty feet falls in some winters; and—different from the coast and in Oregon, where it falls as rain, and at a temperature which does not suspend vegetable action,—here the winter must be complete cessation. But with such great snow-fall the supply of moisture to the soil should be abundant and lasting.

Then the Sierra—much loftier than the coast ranges—rising from 7,000 or 8,000 to 11,000 and 14,000 feet—is refreshed in summer by the winds from the Pacific, from which it takes the last drops of available moisture; and mountains of such altitude, to which moisture from whatever source or direction must necessarily be attracted, are always expected to support

forests,—at least when not cut off from sea-winds by interposed chains of equal altitude. Trees such mountains will have. The only and the real wonder is, that the Sierra Nevada should rear such immense trees!

Moreover, we shall see, that this forest is rich and superb only in one line: that, beyond one favorite tribe, it is meagre enough. Such for situation, and extent, and surrounding conditions, are the two forests—the Atlantic and Pacific—which are to be compared.

In order to come to this comparison, I must refrain from all account of the intervening forest of the Rocky Mountains,—only saying, that it is comparatively poor in the size of its trees and the number of species; that few of its species are peculiar, and those mostly in the southern part, and of the Mexican plateau type; that they are common to the mountain-chains which lie between, stretched north and south *en echelon*, all through that arid or desert region of Utah and Nevada, of which the larger part belongs to the great basin between the Rocky Mountains and the Sierra Nevada: that most of the Rocky Mountain trees are identical in species with those of the *Pacific* forest, except far north, where a few of our eastern ones are intermingled. I may add that the Rocky Mountains proper get from twelve to twenty inches of rain in the year, mostly in winter snow, some in summer showers.

But the interior mountains get little, and the plains or valleys between them less; the Sierra arresting nearly all the moisture coming from the Pacific, the Rocky Mountains all coming from the Atlantic side.

Forests being my subject, I must not tarry on the woodless plain—on an average 500 miles wide—which lies between what forest there is in the Rocky Mountains and the western border of our eastern wooded region. Why this great sloping plain should be woodless—except where some cotton-woods and their like mark the course of the traversing rivers—is, on the whole evident enough. Great interior plains in temperate latitudes are always woodless, even when not very arid. This of ours is not arid to the degree that the corresponding regions west of the Rocky Mountains are. The moisture from the Pacific which those would otherwise share, is—as we have seen—arrested on or near the western border, by the coast-ranges and again by the Sierra Nevada; and so the interior (except for the mountains), is all but desert.

On the eastern side of the continent, the moisture supplied by the Atlantic and the Gulf of Mexico meets no such obstruction. So the diminution of rain-fall is gradual instead of abrupt. But this moisture is spread over a vast surface, and it is naturally bestowed, first and most on the seaboard district,

and least on the remote interior. From the lower Mississippi eastward and northward, including the Ohio River basin, and so to the coast, and up to Nova Scotia, there is an average of forty-seven inches of rain in the year. This diminishes rather steadily westward, especially northwestward, and the western border of the ultra-Mississippian plain gets less than twenty inches.

Indeed, from the great prevalence of westerly and southerly winds, what precipitation of moisture there is on our western plains is not from Atlantic sources, nor much from the Gulf. The rain-chart plainly shows that the water raised from the heated Gulf is mainly carried northward and eastward. It is this which has given us the Atlantic forest region; and it is the limitation of this which bounds that forest at the west. The line on the rain-chart indicating twenty-four inches of annual rain is not far from the line of the western limit of trees, except far north, beyond the Great Lakes, where, in the coolness of high latitudes, as in the coolness of mountains, a less amount of rain-fall suffices for forest growth.

We see, then, why our great plains grow bare as we proceed from the Mississippi westward; though we wonder why this should take place so soon and so abruptly as it does. But, as already stated, the general course of the wind-bearing rains from the Gulf and beyond is such as to water well the Mississippi valley and all eastward, but not the district west of it.

It does not altogether follow that, because rain or its equivalent is needed for forest, therefore wherever there is rain enough, forest must needs cover the ground. At least there are some curious exceptions to such a general rule,—exceptions both ways. In the Sierra Nevada we are confronted with a stately forest along with a scanty rain-fall, with rain only in the three winter months. All summer long, under those lofty trees, if you stir up the soil you may be choked with dust. On the other hand, the prairies of Iowa and Illinois, which form deep bays or great islands in our own forest-region, are spread under skies which drop more rain than probably ever falls on the slopes of the Sierra Nevada, and give it at all seasons. Under the lesser and brief rains we have the loftiest trees we know: under the more copious and well-dispersed rain, we have prairies, without forest at all.

There is little more to say about the first part of this paradox; and I have not much to say about the other. The cause or origin of our prairies—of the unwooded districts this side of the Mississippi and Missouri—has been much discussed, and a whole hour would be needed to give a fair account of the different views taken upon this knotty question. The only settled thing about it, is, that the prairies are not directly

owing to a deficiency of rain. That, the rain-charts settle, as Professor Whitney well insists.

The prairies which indent or are enclosed in our Atlantic forest-region, and the plains beyond this region, are different things. But, as the one borders—and in Iowa and Nebraska passes into—the other, it may be supposed that common causes have influenced both together, perhaps more than Professor Whitney allows.

He thinks that the extreme fineness and depth of the usual prairie soil will account for the absence of trees; and Mr. Lesquereux equally explains it by the nature of the soil, in a different way. These, and other excellent observers, scout the idea that immemorial burnings, in autumn and spring, have had any effect. Professor Shaler, from his observations in the border land of Kentucky, thinks that they have,—that there are indications there of comparatively recent conversion of oak-openings into prairie, and now—since the burnings are over—of the reconversion of prairie into woodland.

I am disposed, on general considerations, to think that the line of demarcation between our woods and our plains is not where it was drawn by nature. Here, when no physical barrier is interposed between the ground that receives rain enough for forest, and that which receives too little, there must be a debateable border, where comparatively slight causes will turn the scale either way. Difference in soil and difference in exposure will here tell decisively. And along this border, annual burnings—for the purpose of increasing and improving buffalo-feed—practiced for hundreds of years by our nomade predecessors, may have had a very marked effect. I suspect that the irregular border line may have in this way been rendered more irregular, and have been carried farther eastward wherever nature of soil or circumstances of exposure predisposed to it.

It does not follow that trees would re-occupy the land when the operation that destroyed them, or kept them down, ceased. The established turf or other occupation of the soil, and the sweeping winds, might prevent that. The difficulty of reforesting bleak New England coasts, which were originally well wooded, is well known. It is equally, but probably not more difficult to establish forest on an Iowa prairie, with proper selection of trees.

[To be continued.]

ART. X.—*On the Structure and Origin of Mountains, with special reference to recent objections to the "Contractional Theory;"* by JOSEPH LECONTE.

(Read before the National Academy of Sciences, April 19, 1878.)

IN order to write intelligibly on this subject it is necessary first of all to define clearly in what sense we shall use the word *mountain*. In popular and even in scientific language this word is used to express every considerable elevation above the general level of the earth surface, whatever be its extent or its mode of origin. It is applied equally to a complex system of ranges formed at different times, such as the Andes, the North American Cordilleras, or the Appalachian; or to each one of the components of such a system, as for example the Coast Range, the Sierra or the Wahsatch: or to each one of the component parts of these components, or even to separate isolated peaks upon these last whether formed by erosion or by volcanic ejections. In this paper I shall call an aggregate of ranges formed at different times a *mountain system or chain*. Each *monogenetic** component of such a system, such as the Sierra I shall call a *Range*. The components of these again, whether formed by erosion or by foldings, or by fissures and slips, I shall call *Ridges*. Isolated peaks, whether of erosion or of volcanic ejections, are so obviously distinct in their mode of origin, that they need not trouble us in this discussion.

Now, a theory of mountain-formation is *essentially a theory of the formation of Ranges*. For, on the one hand a mountain-*system* is but an aggregate of ranges more or less parallel to each other in the same general region but formed at different times, and the addition of range to range in the formation of such a polygenetic system, even though there may be a general bulging of the whole region, introduces no new element in the discussion; and on the other hand the subsequent formation of ridges and peaks by erosion belong not to the category of mountain *formation* at all, but to that of mountain-*sculpture*. Sometimes, it is true, ridges are formed also by faulting, but in all cases they are *subsequent* to the *formation* of the mountain proper—in all cases they belong to the category of mountain *decay*, not to that of mountain-origin. It seems to me that much of the refined classifications, and of the minute divisions and subdivisions of types of mountains, in which some recent writers have indulged is the result of an imperfect recognition of the distinctions enforced above. Limited, as above, mountain ranges are, I believe, *always formed by horizontal pressure*

* A well chosen word often helps greatly to clear up a subject. We are indebted for this one to Professor Dana.

crushing the strata together and thus producing foldings and thickening and consequent elevation. In what I shall say of *mountain-structure* I shall be compelled for the sake of clearness to assume this. I hope to justify this assumption in what I shall subsequently say on *mountain-origin.*

I. *Mountain-Structure.*

Mountain ranges may be conveniently divided into two general classes which, however, graduate completely into each other, viz: those which are composed of a *single anticlinal* fold, and those which are composed of a number of folds alternately anticlinal and synclinal, either open, as in the Jura, or closely appressed, as in the Appalachian, the Coast Range, the Alps, and many others. The one kind is formed where the earth crust is more *rigid*, the other where it *yields* more readily to the horizontal pressure. Both kinds are greatly modified, sometimes by metamorphism, sometimes by faulting, sometimes by volcanic outbursts, and always by subsequent erosion.

1. *Mountains of a single fold.*—The simplest conceivable mountain range consists of a single anticlinal fold of a series of strata. In such cases the deeper strata of the series are thickened and swelled upward by the horizontal pressure, while the upper strata are raised into a vault with little or no thickening, or may even be thinned and broken by tension. Nearly always the yielding is greater on one side than on the other; so that the vault is unsymmetrical. In such cases a great fissure and slip is apt to occur on the steeper side. The following figure (fig. 1) is an ideal section of such a mountain before erosion had modified its form, or rather (since upswelling and erosion goes on together *pari passu*) as it would be if restored. Now it is evident that in the formation of such a vault, fissures would almost certainly be formed; and if beneath the vault there should exist a mass of fused or semi-fused matter (sub-mountain molten matter), formed either by the invasion of the deeper sediments with their included waters, by the interior heat of the earth during the preparatory process of sedimentation, or by the heat evolved by crushing in the act of formation itself of the mountain, dislocations would be apt to occur: and further, both the fissures and the faults would be most apt to occur just where the bending of the strata is

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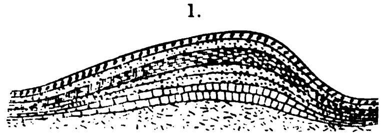

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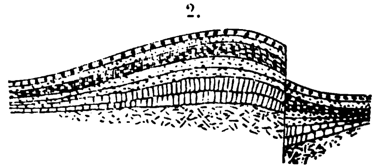

greatest, viz: on the side of the steeper slope. Such a fault is ideally represented in figure 2.

But very few great mountain ranges belong to this simpler type. Perhaps the best illustration which can be found is the Uintah Mountains. The figure given above (fig. 1) may be taken as an ideal simplified restoration of the outline and structure of this mountain. This simple structure, however, is complicated in a portion of its extent by a prodigious fault of 20,000 feet on the north or originally steeper side, just where the bend of the strata is greatest, as in the ideal figure (fig. 2). Figure 3 is a perspective view taken from Powell, showing in

3.

Uintah Mountains—Upper part restored, showing fault; lower part showing the present condition as produced by erosion (after Powell).

its upper part the restored form and the amount of slip on the north side, and in the lower part the amount of subsequent erosion, in this case, 25,000 feet in thickness.

If the crust in the uprising region be *extremely* rigid, then the vault instead of being forty or fifty miles across, as in the case of the Uintah Mountains, may be a hundred or several hundred miles across. In such case a *great plateau* is formed (geanticline of Dana). And since an arch of such extent, whether filled or unfilled beneath with fused or semi-fused matter, cannot sustain itself, such elevated plateaus are peculiarly liable to *fissures* by breaking down of the arch, and to *slips* by gravitative adjustment of the broken parts. If such faults be of comparatively recent origin, or occur in a region where erosion is exceptionally small, then they will form conspicuous escarpments or even conspicuous mountain-*ridges* in the general direction of

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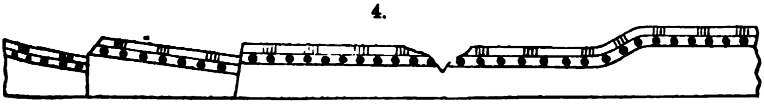

East and west section, across plateau region north of Grand Cañon.

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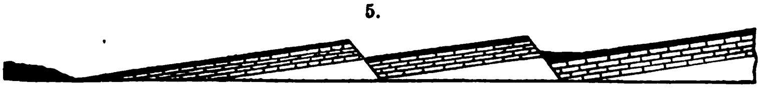

Section east and west across a portion of Utah. (After Howell).

the axis of the uplift. Such is evidently the origin of the north and south escarpments of the plateau-region described by

Powell (fig. 4), and of the north and south monoclinal ranges (*ridges*) in the Basin-region described by Gilbert and Howell (fig. 5). These mountains are evidently formed by the breaking down of a great arch (geanticline). Perhaps the arching and the breaking down may have gone on together *pari passu.* But in any case, certainly the *whole arch* must be regarded as a *monogenetic upheaval* and therefore corresponds to what I have called a *Range*, and the so-called north and south ranges are not ranges but *ridges.*

Again: a simple anticlinal fold such as I have described, may be greatly modified by *metamorphism.* This is especially apt to be the case if the *strata* be very *thick* and the fold be *narrow* and *high*; that is, if the compression in a given space and therefore the *heat* of compression be very great. If now, such a sharp fold, metamorphosed in its deeper strata along the line of greatest compression, be subjected to profound erosion, it forms a common type of mountain, viz: one consisting of a granite or highly metamorphic axis flanked on either side with tilted strata corresponding to each other. The early geologists held, and many even now hold, that in such cases the granite axis was pushed up through the broken and parted strata. But it is far more probable in all cases, and certain in many cases, that the weakened and broken-backed anticlinal has been cut away, and the deeper-seated and therefore metamorphic and therefore also harder strata have been exposed along the axis, as shown in the ideal section, figure 6.

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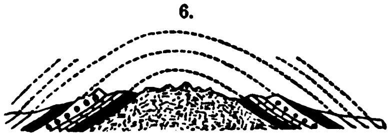

2. *Mountains of many folds.*—We have thus far spoken only of mountains consisting of a single anticlinal fold modified by metamorphism, by faults and by subsequent erosion. But great mountain ranges most commonly consist of many folds, alternately anticlinal and synclinal; either open as the case of the Jura or more usually closely appressed as in the Appalachian, the Coast range of California, and the Alps. The structure of the Appalachian is well known and therefore needs no illustration. The Coast range of California, as I have shown (this Journ., ii, 297, 1876) consists of at least five anticlines and as many synclines closely appressed so that fifteen to eighteen miles of original sea-bottom is compressed into six miles. As this range may be regarded as the type of this class I introduce here the section used in the paper referred to. The structure of the Alps is similar but even

7.

Section across Coast Range, from San Francisco Bay to Livermore Valley, showing plication by horizontal pressure.

more complex. Renevier has recently shown* that the Vaudoise Alps consist of seven anticlines and synclines closely appressed and often even overturned. The *fan-structure* so common in mountains in which the horizontal mashing has been extreme is probably in most cases, the result of an arch strongly pressed together at the base, spreading at the top by its weight, and perhaps broken by tension, and the whole powerfully eroded, as shown in the ideal diagram, fig. 8. This is the view now taken by Favre, by Lory, by Heim and Giordano and other Alpine geologists.† A similar structure, however, may result also from the erosion of a closely appressed syncline, as shown in fig. 9.

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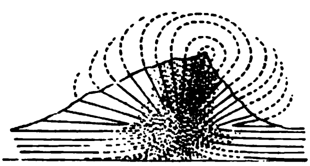

Ideal section showing how fan-structure may be produced by erosion of an anticline.

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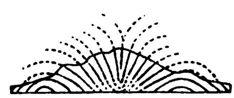

Ideal section showing how fan-structure may be produced by erosion of a syncline.

The kind of mountains just described and of which the Coast Range may be taken as the simplest type, is that which is always formed when the crust of the earth yields sufficiently easily to the horizontally-acting mountain-making force. Of course in such cases the whole mass of crumpled strata is swelled up into a great anticline composed of many smaller alternate anticlines and synclines, like a great wave on which ride many smaller waves. Now, since all the grandest mountain ranges belong to this type, since in these the amount of horizontal compression and therefore the vertical up-swelling is the greatest, it is evident that in these also we find the greatest modifications by contemporaneous metamorphism and by subsequent erosion. These are also equally, with the other kind, subject to fissures and slips; but the slips in this case are not usually *drops*, by gravitative adjustment, but *push-overs* by horizontal pressure. Thus arise two distinct kinds of slips: In the one, the more common or normal, the strata drop on the hanging-wall side of the fissure, in the other or reverse fault, the strata on the hanging-wall side is slidden up and over the other side by the sheer force of the horizontal pressure. The former is characteristic of more gentle foldings and is shown in the figure already given (fig. 5) from the Plateau region; the latter is characteristic of strong foldings, and is well shown in many of the faults of the Appalachian chain, especially in that of

* Archives des Sciences, vol. lix, p. 5, 1877.
† Ibid., vol. xlvi, 301; vol. xlix, 89.

Southern Virginia, described by Rogers and figured by Lesley. It is probable that many early-formed mountain ranges belonging to either type, but especially to the type we have just considered, have been utterly swept away by erosion, leaving only highly metamorphic and crumpled strata to attest their former existence and place. These are in fact extinct mountains—their forms are gone; only their buried and fossilized skeletons remain.

Again: in all mountain ranges, but especially in those of this type, the great swell constituting the range, and often also the subordinate wavelets, are *unsymmetrical*, the slope on one side being long and gentle, and on the other short and abrupt. The *crest is near one side:* the wave is, as it were, ready to break, or has already broken. This asymmetric form has been shown by Suess to exist in the Alps, the Appenines, the Carpathians, the Jura, the Caucasus and nearly all conspicuous mountains. It is admirably shown in the Sierra, the Appalachian, and to a less extent in the Uintah. It may be regarded as the typical form of a monogenetic upheaval (Range). On the steeper side, on account of the great fractures which occur there, the greatest volcanic outbursts are usually found.

The Sierra Nevada may be taken as a typical example both in form and in structure of a monogenetic upheaval, or what I have called a Range. As to *form:* this range rises on its western side from the San Joaquin plains, only about a hundred feet above sea level, by a very gradual slope of fifty to seventy miles in length, until it reaches a crest 12,000 to 15,000 feet in height, and then plunges down by a steep slope which reaches the plains of Lake Mono, or Owen's River valley 5,000 feet high in six or seven miles. As to *structure:* it consists of a granite axis twenty to twenty-five miles wide, flanked on either side by slates and schists dipping at a high angle. Fig. 10 is a generalized section of the Sierra, from the San Joaquin plains, S. J. P., to Lake Mono, L. M., showing the typical contour of a mountain range. On the long western slope the slates and schists outcrop nearly perpendicularly (in many parts, in fact, underdipping the range) for thirty or forty miles, then there occurs a broad interval of granite, twenty to twenty-five miles wide, after which the slates reappear, forming the highest summits, such as Mounts Lyell and Dana, and the whole eastern slope. So simple appears the structure of this mountain, that we might imagine that it consists of only one grand fold, eroded

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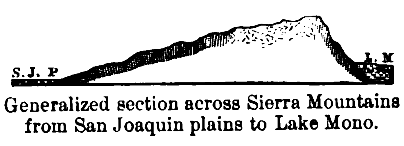

Generalized section across Sierra Mountains from San Joaquin plains to Lake Mono.

along its crest until the granite is exposed, and thus that it falls under the first type. But this is probably not so, because forty miles of slates and schists outcropping at high angle would give an incredible thickness of sediments if we regard them as a single unrepeated series. It is probable, therefore, that these flanking slates really consist of several closely appressed folds, afterward deeply eroded so as to simulate a single series. Fig. 11 is an ideal diagram-restoration of a series of closely appressed folds such as might have formed the Sierra Nevada, showing the grand wave composed of enormous thickness of sediments, the subordinate wavelets, composed of the *upper* crumpled portions of the series, the *lower* portions being metamorphosed into granites and exposed along the axis by erosion.

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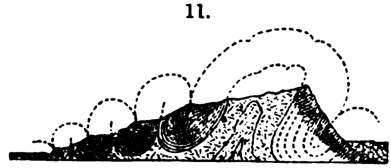

Ideal diagram showing probable structure of the Sierra Nevada range.

Again: the Sierra range is an admirable example of a fold passing gradually into a fault. In the northern portion of Lake Tahoe the slates occupy a broad area on *both slopes*, though largely covered on the eastern slope by volcanic ejections; the two slopes are more equal and the height of the crest is moderate, only about 9,000 to 10,000 feet. The great wave *is more normal* (fig. 12, *a*.) In the middle portion, about Lake Mono, the eastern slate-area is far narrower, the two slopes more unequal and the crest higher, viz: 13,000 feet. The great wave *is ready to break* (fig. 12, *b*). In the southern portion about Lake Owen, the eastern slope is still more abrupt, the eastern slates have entirely disappeared, granite alone forming the summit and the whole eastern wall, and the crest here reaches its highest point, near 15,000 feet. The great wave has *at last broken with the formation of a prodigious fault* (fig. 12, *c*). Remembering that the escarpment is here 10,000 to 11,000 feet, and that the whole thickness of the slates has been removed by erosion from its summit, and that their eastern continuation lies buried beneath the soil of the plains below, we cannot estimate this slip as less than 15,000 feet. It is probably much more. It is almost certain that it was a slight re-adjustment of this slip which caused the Inyo earthquake of March, 1872. In fig. 12, *a*, *b*, *c*, are generalized sections representing these facts. It is on the steep slope side, or else along the crest, that all the great volcanic outbursts have occurred. This is exactly what we

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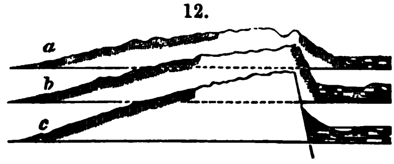


might expect; for the squeezing out of the sub-mountain fused or semi-fused matter would naturally take place there, where both the fissuring and the squeezing are greatest.

In conclusion there are two or three suggestions which seem appropriate here.

a. In the Basin and Plateau regions there occur many parallel north and south faults. In the Plateau region these form escarpments separating *level*, or nearly level *tables*. In the Basin region they form decided north and south ridges. Now it is a remarkable fact that in the southern part of these two regions just where the Plateau is highest, all the western faults of the Plateau region and all the faults of the Basin region drop on their west side, so that the escarpments look westward. But the Sierra escarpment, as we have already seen, looks eastward. Now just between these two, i. e., between the Sierra escarpment on the one side and the Plateau and Basin escarpments on the other and overlooked by both, lies the great depressed area, occupied by the alkaline lakes, Mono and Owen. It is probable that this great depression is correlated with the elevations on each side—that the up-pushing and over-pushing of the Sierra on one side and the elevation of the great Plateau with the formation of the Basin ridges on the other, was attended with a depression of the alkaline-lake region between, causing the escarpments on either side to look that way. It is noteworthy also that just where the *up-folding* of the Sierra on the one side and the up-lifting of the Plateau on the other is greatest, there also the *down-folding* of the intervening basin is also greatest. The wonderful Owen's River valley, with the Sierra near 15,000 feet on one side and the Inyo Mountains 10,000 to 14,000 feet high on the other, with only thirty miles from crest to crest, is this down-folded trough. Only forty miles from Mount Whitney, the highest point on the Sierra and in the United States except Mount St. Elias in Alaska, occurs Death-valley, which is several hundred feet below sea-level.

b. According to M. Suess's view (if I understand him aright), the typical form of mountain ranges described above, is the result of the fact that the yielding crust which by compression and upswelling forms the Range, is abutted against an *un*yielding mass of previously *stiffened crust.* Thus according to him the Alps was pushed over against the resistant crust of the Black Forest and Central France, and, therefore, its steep slope is toward the north. The Appalachian was pushed over toward the already-stiffened Silurian and Laurentian land-crust on the north and northwest. This is a necessary corollary to my view that mountain ranges are the up-pushed sediments of marginal sea-bottoms. For observe: marginal sea-

bottom sediments are thickest near shore, and thin out very gradually seaward. Such sediments, therefore, even before yielding, form a lenticular mass with the thickest part near the shore-edge and are therefore asymmetric. Now this already thickest part is precisely the line of greatest yielding and therefore of greatest upswelling, and thus the mountain-wave becomes very asymmetric with its steeper slope landward. Finally, the already asymmetric mountain is pushed over against the stiffened land crust, making a still steeper slope which may even break on that side.

Now the Sierra is again an admirable illustration of this law. The oldest portion of the western half of the American continent is probably the Basin region, especially its southern portion running down into Mexico. During much of the Paleozoic and all the Mesozoic times until the end of the Jurassic, this was a continental mass with its western shore near the eastern margin of the Sierra region. The Sierra region, as I have elsewhere shown,* was then a marginal sea-bottom receiving sediments from the Basin-region continent, until an enormous thickness had accumulated. When these thick sediments began to yield from the aqueo-igneous softening of their floor, they would first swell up asymmetrically, and then be pushed over against the stiffened Basin region land-crust, forming a steep slope or even a fault and escarpment on that side.

c. I have said that the Basin region was land during Mesozoic times; moreover that the Sierra region was then marginal *Pacific* sea-bottom. Now the Wahsatch region was at the same time *a marginal sea-bottom of the great interior sea* which then covered all the Plateau and Plains region. At the end of the Jurassic, as already said, the marginal sea-bottom on the Pacific side yielded, and the Sierra was born. Probably at the same time the bottom of the Jurassic sea of the Plateau region went down and the more open Cretaceous sea of that region was established. At the end of the Cretaceous period (the process may have *commenced* a little earlier), the enormously thick mass of marginal sea-bottom sediments (56,000 feet according to King), consisting of the whole Paleozoic and Mesozoic series, at last yielded, and the Wahsatch range was born. This mountain wave, also, as it rose, was pushed over to landward until it broke, forming immense faults on that side. According to theory the long slope of this range ought to be on the east or seaward side and the steep slope on the west or landward side. Such according to Emmons is, indeed, the fact. The Wahsatch range rises on the east by a gentle slope twenty miles long, until it attains a crest 12,000 feet high, and then plunges down by a slope so steep that it reaches the plains

* This Journal, III, vol. iv, p. 460 and seq., 1872.

about Salt Lake 4,000 feet high in two miles. The east walls of the faults formed here are 12,000 feet in the air—the west walls lie buried beneath the soil of the plains.*

The same horizontal thrust which pushed up the Wahsatch also arched the stiffened land crust of the basin region and formed the north and south fissures and faults of that region. The basin ridges therefore probably belong to the same time.

d. In passing from the lowest foot-hills, bordering on the San Joaquin plains, to the granite axis of the Sierra, we pass from fine fissile clay-slates through schists of increasing coarseness to granite. This is doubtless partly the result of increasing metamorphic change in this direction. But it is also, I believe, largely due to a change in the character of the original sediments. If the eastern base of the Sierra was once a shore-line, then coarse sandy sediments would have been deposited there while only fine clays and silts would be carried farther out to sea. The metamorphism of the more siliceous material would certainly produce gneiss and schists, while the finer clays by less metamorphism and by pressure would naturally form fissile slates. The stratified materials on the eastern slope nowhere, as far as I know, consist of pure and fine argillaceous matter like those of the western foot-hills. In the formation of this mountain it seems probable that the finer and softer clays at some distance from shore in yielding would be thrown into many small folds, while the somewhat firmer sands nearer shore, though yielding the most beneath, because thickest and therefore most softened aqueo-igneously, would rise as one simple fold, which would then be pushed over and perhaps break on the landward side. I believe it is very important from this point of view to compare carefully the strata on the two sides of mountain ranges. If mountain ranges are upswelled marginal sea-bottoms, then the strata on the two slopes, though corresponding in age, and in fact originally continuous, *ought not to correspond in lithological character.* I believe we have here an answer to Studer's objection to Lory's theory of fan-structure (fig. 8), viz: the non-correspondence of the strata on the two sides of the crest.

II. *Origin of Mountains.*

In all I have thus far said I have assumed that mountain ranges are formed by horizontal pressure in the manner and under conditions already fully explained in my previous papers. Recent observations, both in Europe and in this country, have entirely confirmed this view. I feel quite sure that the more mountain structure is studied the more certain will this view appear. By no effort of the imagination can we even conceive

* Emmons, Survey of 40th parallel, vol. ii, p. 340 and seq.

how a range having the structure of the Appalachian, the Coast range, the Sierra, the Alps or the Caucasus, i. e., a range consisting of many closely appressed folds, could have been formed except by horizontal pressure. It is, I believe, equally *inconceivable that horizontal pressure on a large scale can be produced otherwise than by interior contraction of the earth.* Ranges consisting of a single fold like the Uintah are equally well explained by the same kind of pressure; and therefore it seems unnecessary to seek a different explanation for these. My own conviction therefore is that all mountain ranges have been formed in a substantially similar manner. But since the publication of my papers, some objections have been urged against this conclusion, which must now be examined.

The only serious objection, *based upon structure*, which has ever been made to this view as *applicable to all mountains*, has been advanced by some of the explorers of the Plateau and Basin regions. According to Powell and Gilbert, while many mountains, namely, those of the Appalachian type, including the Appalachian, the Coast range and the Alps, are manifestly formed by horizontal pressure, the great level tables terminated by north and south cliffs of the Plateau region, and the parallel escarped, monoclinal ridges of the Basin region are more probably produced by direct, upward lifting forces. But we have already shown that these are not monogenetic ranges at all, but only the displaced *parts* of one great monogenetic bulge. There has indeed been a vertically acting force concerned in forming these ridges; but it was not a vertically *up-lifting* but a vertically *down-pulling* force. It was a mere gravitative adjustment of the broken parts of the great arch lifted as usual by horizontal pressure.

The objection just mentioned is brought forward by thorough structural geologists educated in the field; the objections now about to be mentioned are on the contrary brought forward by mathematical physicists. The former is an objection not to the contractional theory, but to the *universal applicability* of that theory; the latter are fundamental objections aimed at the theory itself. These physical objections, too, are put forward with so much confidence and with such a bristling array of mathematical formulæ that they seem to many to fall little short of demonstrative certainty. It becomes therefore the more necessary that we should examine them carefully.

The first objection is this: It is said that interior contraction *cannot concentrate its effects along certain lines* (viz., mountain ranges) *without a slipping or a shearing* of the exterior shell upon the interior nucleus; but such slipping is impossible in a *solid earth.* I have long felt this as a really serious objection to the special form of the contractional theory expressed in my

paper. But, let it be borne in mind that it is *no objection at all to the contractional theory, but only to that form of it which assumes the complete solidity of the earth.* There can be no difficulty in the way of concentration of the effects of interior contraction along certain lines so as to give rise to mountain ranges, if the earth be liquid beneath a solid crust, as maintained by some; or if there be a layer of aqueo igneously fused or semi-fused matter between a solid crust and a solid nucleus,* as maintained by many of the very best geologists. To the idea of a substantially liquid earth covered only with a thin solid shell, I believe there are insuperable objections; but the existence of a layer of semi-fused matter would not interfere with the substantial solidity of the earth in all its cosmical relations. The concentration of lateral crushing along certain lines seems to require not however an universal semi-liquid sub-crust layer but only large areas of the crust thus underlaid. These areas are undoubtedly the ocean beds which, as we have already said in our previous paper, are the most contractile portion.

A second objection urged against the contractional theory is this: the *amount of contraction* produced by secular *loss of heat*, it is said, is wholly *inadequate* to produce the foldings which we actually find, being in fact demonstrably very small. Now assuming that, in so complex a problem, all the data are correct and the reasoning logical (a large assumption, when we remember the difference of views among the best physicists on some geological questions and the frank admission of grave error, recently by one of the most eminent),† allowing I say the objection its full weight and all the certainty claimed for it; still it is evident that this is no objection at all to the contractional theory; but, again, only to a particular form of that theory, viz: that which assumes the contraction to be the result *solely of loss of heat.* This, it is true, has seemed the most obvious cause of contraction. It is certainly a *true* cause even if it be not by itself a *sufficient* cause. There are, however, other causes of contraction conceivable, and perhaps still others not yet dreamed of. Other things besides the earth shrink and shrivel, and in some cases without loss of heat. Apples shrivel by loss of moisture, and old people's faces wrinkle for the same reason. Now is it not barely possible that there may be other causes of shrinkage of the earth and the wrinkling of its face, besides loss of heat?

It is well known that immense quantities of gas and vapors, especially steam, issue from volcanoes. This steam is usually, and perhaps truly, supposed to be derived from above—to be,

* Fisher, Phil. Mag., vol. 1, p. 317, 1875.

† Sir Wm. Thomson's Address, before British Association, 1876. This Journal, xii, 336.

in fact, percolating meteoric water. But O. Fisher* believes that volcanoes are the vents of superheated gases and steam *from the interior*—so superheated that they fuse their way to the surface and so escape. These gases and steam, according to him, are not meteoric but *original and constituent*. This view of the cause of volcanoes has been highly commended by the distinguished vulcanologist Scrope, and at least deserves the serious attention of geologists. If this be the true origin of volcanic water, then in its escape we would have another important factor of contraction, although perhaps, by itself, also inadequate.†

In a word, it is probable that in the present condition of science we do not know all the causes of contraction. But the *fact* of contraction is one thing and the *cause* of contraction another and quite a different thing. The fact of contraction is not conditioned on our knowledge of the causes of contraction but *rests wholly upon the phenomena of structure*. If loss of heat be inadequate, then we must seek some additional cause. If all known causes be inadequate, then we must frankly acknowledge our ignorance and seek still other causes yet unknown.

The great importance of separating these two things and keeping them distinct in the mind, may be illustrated by examples. In nearly all complex subjects there are two stages of theorizing and therefore two successive theories. The one discusses and determines the laws of phenomena and the conditions under which they occur—*Formal theory*; the other discusses the physical cause of these laws—*Physical theory*. Slaty cleavage is undoubtedly produced by mashing in a direction at right angles to the planes of cleavage and extension in the direction of those planes. This is completely proved both by observation and experiment. This is the *Formal theory*. It groups a multitude of facts and consistently explains them and is therefore properly called a theory. But still the question remains: how does crushing produce cleavage? Sorby thinks by change of position of foreign unequiaxed particles disseminated in a plastic mass; Tyndall thinks by the flattening of constituent granules into scales. These are *Physical theories*. Now it is evident that the former theory, the formal, is independent of the latter, the physical, and in fact forms its basis; but not vice versa. So again it is certain that glaciers conform to the laws of fluid motion. This is the *Formal theory*; it reduces to law, and consistently explains all the phenomena of glacial motion. But still the question remains. By virtue of

* Cambridge Phil. Trans., vol. xii. part II; Feb., 1875.

† Even while writing this, I see that Tschermak brings forward a similar theory of vulcanism and connects it with many cosmic phenomena, such as solar explosions of gas, new stars, explosion of meteors, &c.—(*Geol Mag.*, vol. iv, 569, 1877.

what property do they thus move? Forbes answers, by a property of viscosity; Tyndall answers, by fracture, change of position and regelation. These are Physical theories. Observe again: the formal theory is independent of the physical and forms its basis; but not vice versa. Now in both these cases it will be observed that it is the formal theory which is most important to the geologist. That slaty cleavage is produced by mashing together horizontally and upswelling vertically, or that glaciers move in the manner of a stream, is of immense importance to the geologist; but the molecular cause of either is of great interest only to the physicist. When slaty cleavage was proved to be the result of compression horizontally and upswelling vertically the geological problem was solved; and the subject was then handed over to the physicists for further discussion.

Now on the question of mountain origin we find the same two kinds of theories: That mountain ranges are formed by horizontal pressure crushing rock masses together in that direction and upswelling them vertically, is certain; and that this horizontal pressure is due to interior contraction of the earth is almost equally certain. This is the *formal theory.* But still the question remains: What are the physical causes of interior contraction? The discussion of this is the *physical theory.* The former we have shown is nearly perfect; the latter is yet very imperfect. The geological problem is well nigh solved; the question must now be handed over to the physicists for further discussion. But we must insist that the physicist shall make the formal theory already established by the geologist the basis of his discussion. But observe again that it is the formal theory which is of the greatest and most immediate importance to the geologist, though the physical theory may be the most so to the physicist.

The two physical objections which I have just taken up and, I hope in part at least, answered, are brought forward by Rev. O. Fisher* and Captain C. E. Dutton.† They are by far the most serious. But there are other minor objections advanced by Captain Dutton which I must, at least briefly, notice.

We are concerned in this paper only with the origin of *mountains;* but in my paper on "A Theory of the formation of the greater features of the Earth surface," I discussed also the origin of *continents.* I attributed those *greatest* inequalities constituting continental surfaces and ocean bottoms to *unequal radial contraction* or a *secular deformation*, by cooling, of a heterogeneous earth. The same idea had been previously

* "On the Inequalities of the Earth Surface," &c., Cambridge Phil. Trans., vol. xii, part 2d, Dec., 1873, and Cambridge Phil. Trans., vol. xii, part 2d, Feb., 1875.

† "Critical Observations on Theories of the Earth Physical Evolution," this Journal, viii, 113, 1874; Penn Monthly, May, 1876.

brought out by Professor Dana and Archdeacon Pratt; and the latter had at one time extended the idea so as to include also mountain chains, although he afterward admitted lateral pressure as the more probable cause of these latter. Now, according to the view that continents and ocean bottoms are formed by *unequal radial contraction by loss of heat*, of course the *less* conductive parts would become *continents* and the *more* conductive parts *ocean bottoms.* Now Captain Dutton has brought against this view certain geological facts. The Himalayas, he says, were ocean bottom until late in the Tertiary (as indeed they were); and now these Tertiary ocean-bottoms are 15,000 feet above sea level. Therefore, certainly, all this enormous rise (and probably much more, viz: the elevation of the whole height of the Himalayas) took place since the Middle Tertiary. (This is also certainly true.) Then, says he, we must believe, according to the radial contraction view, that until the Tertiary, *this radius* of the earth was very conductive, *and became at that time suddenly very non-conductive!!!* He gives the Alps as another example of a Tertiary sea-bottom which has since been raised 10,000 feet, and which, therefore, according to him, must have suddenly changed its conductivity.* He might have multiplied examples by adding all other mountain ranges; for the principle involved is the same in all.

It seems almost unnecessary to state that there is here an entire and most unaccountable misapprehension of the meaning of all who have written on this subject. The formation of the Himalayas and the Alps *come under the head of mountain origin*, not of continent formation. Neither Professor Dana nor myself ever for a moment imagined that the elevation of the Himalayas and the Alps was due to unequal radial contraction. Mountain ranges have always been formed comparatively rapidly, continents very slowly and progressively. We know the time of birth of mountains; but continents, in spite of some oscillations difficult to account for, have substantially continued to develop in size and height throughout the whole geological history of the earth. This is what we would expect if they are due to unequal radial contraction.†

Again, Captain Dutton makes still another objection (loc. cit., p. 377) to the mechanics of the contractional theory, the force of which I confess I do not understand. He seems to think there is a principle of economy of force in nature by virtue of which we must infer that she applies force in that

* Penn Monthly, May, 1876, p. 372.

† Archdeacon Pratt, it is true, in the earlier editions of his "Figure of the Earth," attributed the formation of mountain chains, especially the Himalayas, to unequal radial contraction, but in his fourth edition he makes lateral compression the cause of mountains. This is evidently the origin of Captain Dutton's misconception.

direction which will accomplish the required result with the *minimum expenditure.* Now he says, to make a mountain range by *horizontal* pressure would require demonstrably, a *maximum,* and by *vertical* pressure a *minimum,* expenditure of force, in proportion to the height and mass lifted. Therefore he thinks mountains must be formed by vertically acting forces, upward for anticlines and downward for synclines. The streets of San Francisco are many of them paved with wooden blocks, which swell by wetting and are pushed up into ridges, as everybody supposes, by horizontal pressure. But according to Captain Dutton these ridges are not formed by horizontal pressure, because this mode necessitates a maximum expenditure of force in proportion to the *visible* work done.

But again Captain Dutton thinks that the crust of the earth, under horizontal pressure, would not and could not yield gradually and quietly so as to retain its continuity, but would shiver into fragments—it would not *mash,* but *smash* and "*go to pi.*"

I will not inquire how far this is good physics; because until geological physics is far more perfect than now, i. e., until we understand far better than we now do, the *precise conditions* under which physical forces acted in producing geological results, geological problems must often continue to be questions of *history* rather than questions of *physics*—questions of what *did happen,* rather than questions of what, according to physical laws, *ought to have happened.* Now we have abundant evidence, of the most indubitable kind, of quiet yielding of the earth's crust to horizontal pressure. It is absolutely certain, for example, that slaty cleavage is produced by horizontal mashing; and that the mashing is so great that originally equal diameters are changed into diameters having a ratio of 1 : 5, 1 : 10, or even 1 : 14; yet there is no smashing or "*going to pi,*" but only quiet yielding, like dough or plastic clay. Again, in mountain ranges consisting wholly of crumpled strata with many folds closely appressed, without even a granite axis, like the Appalachian or the Coast Range of California, it is simply inconceivable that the crumpling force should have acted in any other direction than horizontally; yet the strata, though sometimes broken and slipped, are in large measure continuous; there is no shivering into rubble, like "pack ice driven against a shore." As to the condition of the strata at the time when these results were accomplished, i. e., whether or not they were more plastic then than now, is another question, and one with which we are not now as structural geologists concerned. But this is precisely the question which Capt. Dutton as physicist should have discussed. Here are strata in positions such that it is inconceivable they could have been assumed except by hori-

zontal pressure; but their hardness and brittleness is such that horizontal pressure would have smashed them into rubble; therefore Capt. Dutton concludes the force was not horizontal. But would it not have been better to conclude: therefore the strata were not then so hard and brittle as now?

Again, and finally: Captain Dutton objects, that contractional theorists give no reason "*why lines of thick strata should be lines of weakness*," and thus by yielding produce mountain ranges, "*nor why the epoch of disturbance (mountain formation) should coincide with or immediately follow the epoch of deposit.*" This sentence raises the doubt whether Captain Dutton has read what has been written on this subject by Hunt, Dana and myself, or whether having read he has not forgotten them. For not only is the reason insisted on both by Hunt and myself, but there has been some discussion as to priority in regard to this important idea. The idea is undoubtedly due to Hunt, but I have, I believe, made more use of it and shown its fundamental importance in mountain making. It is, in fact, the corner stone of my theory, which is briefly this: The place of a mountain range before it was formed was a marginal sea-bottom receiving abundant sediment from continental erosion. A line of off-shore sediments many thousand feet thick, thus formed would cause a rise of the subjacent iso-geotherms, and aqueo-igneous softening both of the sediments and of the original crust on which the sediments were laid down. This would determine a line of weakness and therefore of yielding to horizontal pressure; and therefore the formation of a mountain range, which would immediately commence to be sculptured by erosive agents.

Thus there are three stages in the history of a mountain range. First, a stage of preparation by sedimentation; this is the embryonic stage. Second, a stage of yielding to horizontal pressure; this is the period of mountain birth and mountain growth. Third, a stage of erosive degradation; this is the period of mountain decay. This last passes gradually into a fourth stage of mountain death and fossilization.

We have now examined all the objections which have been so confidently brought against the contractional theory. Of these objections we find only two which are at all serious; and these affect not the *substance* but only the *form* of that theory—not the geological *foundation*, but only some of the physical abutments. These two objections, however, are well worthy of serious attention as important additions to dynamical geology which ought to, and doubtless will, be used to modify the contractional theory as it now exists.

Of Captain Dutton's own theory, which he proposes to substitute in place of the supposed dead contractional theory, I

will say nothing: partly because to do so would transgress the limits which I proposed to myself at the outset, and partly because after reading and re-reading several times I find it impossible to hold any clear image of the new theory in my mind, and I fear therefore that I might do the author injustice.

Berkeley, California, April 1, 1878.

ART. XI.—*On the occurrence of a Solid Hydrocarbon in the Eruptive Rocks of New Jersey*; by I. C. RUSSELL.

(Read before the New York Academy of Sciences, April 29, 1878.)

IN an article by T. Sterry Hunt, published in this Journal in 1863,* mention is made of an interesting locality at Cape Gaspé where a trap dike intersects the sedimentary rocks. The cavities in the trap are frequently lined with chalcedony, or with crystals of calcite or quartz, and filled with petroleum which in some cases has assumed the hardness of pitch. Recently our attention was called to a newspaper account of the occurrence of mineral oil in the lava of Mt. Etna. The numerous round or irregular cavities contained in the lava are described as being coated with aragonite and filled with mineral oil. An analogous instance in our own country has been familiar to me for some time, which, taken in connection with the occurrences mentioned above, seems to be of sufficient interest to be worth recording.

Associated with the sheet of trap rock known as the First Newark Mountain, which traverses the central portion of the Triassic formation of New Jersey, there occurs near Plainfield, at an abandoned copper mine on the western slope of the mountain—the upper surface of the trap sheet—an amygdaloid trap passing into a metamorphosed shale. In this region it is frequently impossible to distinguish in small exposures, the genuine trap from the metamorphosed shales that rest in contact with it.† Many of the cavities in the amygdaloidal rock are filled with a brilliant jet black carbonaceous mineral resembling very closely the albertite of New Brunswick.‡ These cavities are frequently tubular in shape, having a length of three or four inches and usually a diameter of about a quarter of an inch. Sometimes these tubes were lined throughout by infiltration, with a coating of quartz or calcite a line or

*Vol. xxxv, p. 166, 1863.

† See article by the writer "On the Intrusive Nature of the Triassic Trap Sheets of New Jersey," in this Journal, xv, 277, 1878.

‡ The occurrence of "bitumen" in amygdaloid trap is briefly mentioned by E. S. Dana in an article on the Trap Rocks of the Connecticut Valley. Am. Assoc. Sci., 1874, B 47 [also, with an explanation of its origin, by G. W. Hawes, in this Journal, ix, 456, 1875.]

two in thickness, before the carbonaceous material was introduced. Above the amygdaloid is found a metamorphosed shale which still retains its bedded structure, and in places presents something of the usual reddish color of the unaltered shales. This altered rock is traversed in various directions by seams and fissures, which are frequently filled with the same albertite-like mineral. Resting upon these metamorphosed beds occur slates, shales and sandstones, which contain fossil fishes and a considerable abundance of obscure vegetable remains. It seems evident that these organic bodies furnished by their decomposition the carbonaceous material in the associated rocks. The heat derived from the slowly cooling injected rocks may have played an important part in this process.

The mineral whose geological occurrence we have thus described, gives, when subjected to chemical tests, almost precisely the same reactions as albertite. It is insoluble in heated acids and alkalies, and is but sparingly if at all soluble in alcohol, ether, or oil of turpentine. Like albertite, also, it is infusible, but softens by heat and burns with a yellow flame, emitting an agreeable odor. It gives when incinerated less than 0·10 per cent of ash.

The occurrence of petroleum in the cavities of the igneous rocks of Gaspé and Sicily, and of a solid hydrocarbon in the trap rocks of New Jersey would seem to be but different stages in the same process. If the cavities in a rock were filled with petroleum by infiltration, and evaporation slowly removed the more volatile portions, and oxidation took place to some extent, the result would be the formation of a deposit of solid hydrocarbon in the cavities. A similar process sometimes occurs with bottled samples of petroleum, by which the interior of the bottle is left coated with a solid carbonaceous layer. In the rocks, if a fresh supply of oil was furnished from time to time by infiltration, the cavities would eventually become completely filled with the solid carbonaceous residue. A vesicular lava might in this manner be changed to an amygdaloid, the cavities of which would be filled with solid hydrocarbons instead of quartz, zeolites, etc.

Such, it appears to us, must have been the history of the Triassic amygdaloid we have described, the cavities of which must at one time have been filled with mineral oil. This is but an epitome of what took place on a grand scale at the great fissure over 1,400 feet deep, in New Brunswick, which was filled with albertite, and in the case of the Grahamite in West Virginia, which also occupies an immense fissure.

Since writing the above, our attention has been called, through the kindness of Prof. J. D. Dana, to the fact that Percival in his report on the geology of Connecticut, published in

1842, records the occurrence of "bitumen" in connection with the trap rock of Connecticut. Those who are fortunate enough to possess a copy of this report will find that Percival with his usual accuracy of observation, mentions several times the occurrence of this substance while describing the Triassic formation of the Connecticut Valley. Mr. Percival speaks particularly of "indurated bitumen" as occurring in the cavities of amygdaloid trap, and in small veins in the indurated shale adjoining. Associated with these rocks occur, also, bituminous limestones and shales containing fossil fishes. Similar bituminous rocks he describes as occurring in the small isolated Triassic area of Southbury and Woodbury in Western Connecticut. In reference to the reported discovery of coal in Connecticut the statement is made* that "This substance, however, is a more or less indurated bitumen, similar to that occasionally occupying the pores of amygdaloid, or accompanying metallic veins in the trap and the adjoining indurated sandstones, and is perhaps derived from the same volcanic source as the trap it accompanies."

It will be noticed from the above that the bitumen described by Percival has the same geological associations as the mineral occurring at Plainfield, N. J. A specimen of this mineral from Connecticut which we have just received from Dr. H. C. Bolton of Trinity College, and obtained by him from seams in trap rock near the new college buildings at Hartford, seems identical in its physical and chemical properties with the solid hydrocarbon we have described from New Jersey. The rocks with which this mineral is associated in Connecticut correspond in lithological characters and geological position with the eruptive rock of New Jersey, and are a portion of the great system of trap ridges which traverse the Triassic formation in Connecticut and Massachusetts.

ART. XII.—*On a new and remarkable mineral locality in Fairfield County, Connecticut; with a description of several new species occurring there;* by GEO. J. BRUSH and EDWARD S. DANA. First Paper.

[Continued from page 46.]

3. DICKINSONITE.

Physical characters.—Dickinsonite occurs most commonly in crystalline masses, which have a distinctly foliated, almost micaceous, structure. It is also lamellar-radiated and sometimes stellated, the laminæ being usually more or less curved. This massive variety forms the gangue in which crystals of eosphorite are often imbedded, and also sometimes triploidite. It more-

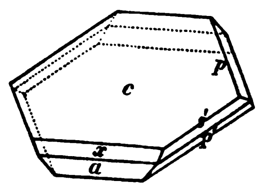
* Percival's Geol Rep. of Conn., p. 452.

over occurs in minute scales distributed through the massive eosphorite and giving it a green color, and is sometimes imbedded in the rhodochrosite. Minute tabular crystals are rare; they are observed implanted upon the gangue, and also scattered through the reddingite. In general aspect the mineral resembles some varieties of chlorite though very unlike in its brittleness.

It has perfect basal cleavage. The hardness is 3·5–4, and the specific gravity 3·338–3·343. Luster vitreous, on the cleavage face somewhat pearly. The color of the purest crystal is oil- to olive-green, in the massive varieties generally grass-green though sometimes quite dark; the streak is nearly white. Transparent to translucent, the crystals being perfectly clear. The laminæ are very brittle; fracture uneven.

Crystalline form.—Distinct crystals of dickinsonite are not often found, and owing to the extremely brittle character of the mineral, it is only in very rare cases that they can be obtained showing more than the basal plane. The crystallographic data which are given here were all obtained from two crystals, which, though extremely small and yielding only approximate angles, yet served to decide all the essential points. Other less perfect crystals gave confirmatory results.

5.



Dickinsonite crystallizes in the MONOCLINIC SYSTEM. The axial ratio and obliquity were obtained from the following angles:—

Plane angle of the base = 120° 0′
$c \wedge a$, 001 ∧ 100, = 61° 30′
$c \wedge x$, 001 ∧ 301, = 42° 30′

The axial ratio is:—

$\dot{c}$ (vert.)	$\bar{b}$	$\grave{a}$	
0·6917	0·5773	1·0000	β=61° 30′

For the unit prism (not observed),

$I \wedge I$ = 66° 36′, and 113° 24′

The observed planes are as follows:—

c,	*O*,	001.	*p*,	1,	$\bar{1}$11.
a,	*i*-$\bar{i}$,	100.	*s*,	2,	$\bar{2}$21.
b,	*i*-$\grave{i}$,	010.	*x*,	-3-$\bar{i}$,	301.

The adjoining figure shows all of these planes except the clinopinacoid, which was only once observed.

The following are the most important angles, measured and calculated:

			Calculated.	Measured.
$c \wedge a$,	$001 \wedge 100$,	=	*61° 30′	
$c \wedge x$,	$001 \wedge 301$,	=	*42° 30′	
$c \wedge p$,	$001 \wedge \bar{1}11$,	=	61° 8′	61°–62°
$c \wedge s$,	$001 \wedge \bar{2}21$,	=	82° 2′	82°–82° 30′
$a \wedge x$,	$100 \wedge 301$,	=	19° 0′	
$a' \wedge p$,	$\bar{1}00 \wedge \bar{1}11$,	=	81° 7′	
$a' \wedge s$,	$\bar{1}00 \wedge \bar{2}21$,	=	68° 22′	68°
$b \wedge p$,	$010 \wedge \bar{1}11$,	–	40° 40′	
$b \wedge s$,	$010 \wedge \bar{2}21$,	=	30° 56′	
$p \wedge p'$,	$\bar{1}11 \wedge \bar{1}\bar{1}1$,	=	98° 40′	
$s \wedge s'$,	$\bar{2}21 \wedge \bar{2}\bar{2}1$,	=	118° 9′	

It will be seen from the above table that the angle between the base and one of the two pyramids ($c \wedge p = 61° 8'$) differs but little from the angle between the base and the orthopinacoid ($c \wedge a = 61° 30'$); there are thus three planes which have nearly equal inclinations to the base. This fact, which is analogous to that true of the Vesuvian biotite (meroxen) as pointed out by Tschermak,* gives to the crystals a marked *rhombohedral* aspect especially as the planes x (301) and s ($\bar{2}21$) have usually a minor development. As exact measurements were not possible the true relations could hardly be established beyond doubt until recourse was had to an optical examination. This showed that the cleavage planes are not isotrope as they must be if rhombohedral; on the contrary one plane of vibration is exactly parallel to the edge c / a, and the other normal to it.

The rhombohedral pseudo-symmetry is also shown in the fact that the plane angle of the base differs very little if at all from 120°. The most careful measurements practicable failed to establish any variation. That the angle really is 120° seems, moreover, to be indicated by the fact that on many cleavage laminæ triangular markings are visible, which are apparently equilateral the angles measuring 60°; other analogous markings have four or five sides but always with angles of 60° or 120° as near as the measurements can be made.

The above facts show that crystallographically dickinsonite is related to the micas and chlorites, although most unlike chemically.

The plates of dickinsonite are sometimes striated parallel to the edges c / p, c / p', and also c / a, corresponding to the triangular markings mentioned and still more increasing the rhombohedral aspect of the crystals. No twins have been observed, although some very imperfect crystals early suggested their possible occurrence.

The cleavage plates show a marked dichroism, parallel to the edge c / a, the rays being grass-green and much absorbed

* Groth, Zeitschrift für Krystallographie, ii, p. 19, 1877.

and normal to this yellow-green. No examination of a section perpendicular to the cleavage was possible, so that the position of the axes of elasticity in the plane of symmetry could not be determined.

Chemical composition.—The following analysis was made by Mr. S. L. Penfield. The method of analysis was essentially the same as that already described. The purest material available was selected, but it was found impossible to separate it entirely from a little admixed quartz and eosphorite. The small amount of alumina present is assumed to belong to the eosphorite, and the calculations made accordingly. In the table below, column (1) gives the original analysis; (2) gives the amount of each constituent of the impurities to be deducted; (3) gives the remainder after this deduction has been made, and (4) the final composition after being averaged up to the original amount.

	(1)	(2) Eosphorite and quartz.	(3)	(4)
P_2O_5	37·49	2·13	35·36	39·36
AlO_3	1·55	1·55		
FeO	11·64	·50	11·14	12·40
MnO	24·18	1·63	22·55	25·10
CaO	12·00		12·00	13·36
Li_2O	·03		·03	·03
K_2O	0·80		0·80	·89
Na_2O	4·71		4·71	5·25
H_2O	4·55	1·08	3·47	3·86
Quartz	3·30	3·30		
	100·25	10·19	90·06	100·25

The ratio calculated from analysis (4) is as follows:—

$$
\begin{array}{lll}
P_2O_5 = \cdot277 & \cdot277 & 1\cdot \quad 4\cdot \\
\left.\begin{array}{l} FeO = \cdot172 \\ MnO = \cdot353 \\ CaO = \cdot238 \\ Li_2O = \cdot001 \\ K_2O = \cdot009 \\ Na_2O = \cdot085 \end{array}\right\} & \cdot858 & 3\cdot09 \quad 12\cdot \\
H_2O = \cdot215 & \cdot215 & 0\cdot77 \quad 3\cdot
\end{array}
$$

The ratio $P_2O_5 : RO : H_2O = 4 : 12 : 3$ corresponds to the formula $R_3P_2O_8 + \frac{3}{4}H_2O$. If $R = Mn : Fe : Ca : Na = 5 : 2\frac{1}{2} : 3 : 1\frac{1}{2}$; this formula requires:—

$$
\begin{array}{lcr}
P_2O_5 & = & 40\cdot05 \\
FeO & = & 12\cdot69 \\
MnO & = & 25\cdot04 \\
CaO & = & 11\cdot85 \\
Na_2O & = & 6\cdot56 \\
H_2O & = & 3\cdot81 \\
\hline
& & 100\cdot00
\end{array}
$$

This corresponds as closely as could be expected with the analysis (4) given above.

Another analysis by Mr. Penfield on a separate sample of dickinsonite is given below, the lime having been lost is determined by difference. The results are arranged as before: (1) is the original analysis; (2) the amount of quartz and eosphorite present; (3) the result after deducting these, and (4) the final result calculated again to 100.

	(1)	(2) Eosphorite and quartz.	(3)	(4)
P_2O_5	38·18	2·13	36·05	39·53
AlO_3	1·55	1·55		
FeO	11·36	·50	10·86	11·90
MnO	23·48	1·63	21·85	23·96
CaO	[13·67]		[13·67]	[14·98]
Li_2O	·22		·22	0·24
K_2O	·67		·67	·73
Na_2O	4·36		4·36	4·78
H_2O	4·62	1·08	3·54	3·88
Quartz	1·89	1·89		
	100·00	8·78	91·22	100 00

Pyrognostics.—In the closed tube gives water, the first portions of which react neutral to test paper, but the last portions are faintly acid. The residue is magnetic. Fuses in the naked lamp flame and B.B. in the forceps colors the flame at first pale green then greenish yellow. Dissolves in the fluxes and affords reactions for iron and manganese. Soluble in acids.

There is no known phosphate, so far as we are aware, which bears any relation to dickinsonite in crystallographic character, and in chemical composition it seems also to be without any very near relatives.

We have named this most interesting mineral *dickinsonite* in honor of the Rev. John Dickinson of Redding, Conn., our obligations to whom we have already acknowledged.

4. Lithiophilite.

The occurrence of this mineral in the deepest explorations made has already been mentioned. It is found imbedded in albite in irregular rounded masses one to three inches in diameter and coated with a black mineral, the result of its own oxidation; some of these masses have only a small core of unaltered mineral.

Physical characters.—No crystals of lithiophilite were found, although some of the imbedded masses have in external form a somewhat crystalline aspect. There are three distinct cleavages: one quite perfect, always observable whenever the mineral is broken; a second nearly perfect at right angles to the first; and a third interrupted, which is prismatic, having an angle of 128°–130°, and inclined at right angles to the first named cleavage, and 115°–116° to the second. The similarity in composition

between this species and triphylite makes it possible to identify these three cleavages with those shown by Tschermak to belong to the latter mineral: the most perfect cleavage is basal, the second nearly perfect is brachydiagonal, and the third interrupted cleavage is prismatic ($I \wedge I = 133°$ triphylite, Tschermak).

The hardness is about 4·5; and the specific gravity, in two trials, 3·424, and 3·432. The color of the unaltered mineral is generally bright salmon-color, occasionally honey-yellow,—varying to yellowish-brown and on rare instances to umber-brown; this darker color is probably due to incipient alteration. It has a vitreous to resinous luster, and is generally translucent, though small cleavage fragments are occasionally perfectly transparent. Fracture uneven to subconchoidal.

Optical properties.—The optic axes in lithiophilite lie in the basal section or plane of most perfect cleavage, the acute bisectrix being normal to the brachypinacoid. The axial angle is very large the axes being partially visible in the extreme border of the field in the polariscope. The angle could not be measured satisfactorily except in oil ($n = 1·47$); the result of the measured was as follows:

$$2H\alpha = 74° \; 45' \text{ for red rays.}$$
$$2H\alpha = 79° \; 30' \text{ for blue rays.}$$

The dispersion of the axes is strong, $v > \rho$. The character of the double refraction is positive. The three axial colors are quite distinct, as follows:

For vibrations parallel to			$\mathfrak{a}$	(that is) $\breve{a}$	deep pink.
"	"	"	$\mathfrak{b}$	(that is) c	pale greenish-yellow.
"	"	"	$\mathfrak{c}$	(that is) $\bar{b}$	faint pink.

Chemical composition.—The following analyses are by Mr. Horace L. Wells. The method was the same as that employed by Mr. Penfield in the analysis of triphylite (see beyond).

	I.	II.	Mean.	Quantivalents.		Ratio.	
P_2O_5	44·83	44·51	44·67	·314	·314	1·	1·
MnO	40·80	40·91	40·86	·576	·632	2·01	2·
FeO	3·99	4·04	4·02	·056			
Li_2O	8·72	8·55	8·63	·288	·290	0·93	1·
Na_2O	·13	·16	·14	·002			
H_2O	·77	·87	·82				
SiO_2	·63	·66	·64				
	99·87	99·70	99·78				

The ratio $P_2O_5 : \overset{\text{II}}{R}O : \overset{\text{I}}{R}_2O = 1 : 2 : 1$ proves lithiophilite to be a normal phosphate analogous in composition to triphylite. Its formula is $LiMnPO_4$ or $LiPO_4 + Mn_3P_2O_8$. This formula requires:—

P_2O_5	45·22
MnO	45·22
Li_2O	9·56
	100·00

The mineral lithiophilite is consequently a manganese member of the triphylite group. Mr. Penfield has previously shown that the true formula of triphylite, hitherto doubtful, is $\overset{\text{I}}{R}_3PO_4+\overset{\text{II}}{R}_3P_2O_8$,* where $\overset{\text{I}}{R}$=Li, and $\overset{\text{II}}{R}$=Fe mostly, also Mn. His conclusions are confirmed by the results of Mr. Wells' analysis of lithiophilite.

Rammelsberg found (as a mean of four analyses) in the Bodenmais mineral 39·97 p. c. FeO, and 9·80 p. c. MnO. Mr. Penfield, in his analysis of the Grafton, New Hampshire, obtained 26·09 p. c. of FeO and 18·17 p. c. MnO. The altered triphylite from Norwich, Mass., also contains a considerable amount of manganese, but as manganese sesquioxide (22·59–24·70 p. c.); the unaltered mineral has never been analyzed. These facts go to show that between the true triphylite,—the *iron*-lithium phosphate—,and the lithiophilite,—the *manganese*-lithium phosphate—a number of different compounds exist, containing varying amounts of iron and manganese, as is true in many other analogous cases of isomorphous groups of compounds. It is probable, however, that to all varieties of the two minerals belongs the general formula:—

$$\overset{\text{I}}{R}_3PO_4+\overset{\text{II}}{R}_3P_2O_8.$$

Pyrognostics.—In the closed tube gives traces of moisture, turns dark-brown and fuses but does not become magnetic. Fuses in the naked lamp-flame and B.B., gives an intense lithia-red flame streaked with pale green on the lower edge. Dissolves in the fluxes giving in O.F. a deep amethystine bead, and in R.F. a faint reaction for iron. Soluble in acids.

The name lithiophilite, from *lithium* and *φιλός*, *friend*, may properly be given to this species as it contains a very high percentage of lithia.

5. REDDINGITE.

Physical characters.—Reddingite occurs sparingly in minute octahedral crystals, belonging to the *orthorhombic system*. It is also found more generally massive with granular structure; it is associated with dickinsonite, and sometimes with triploidite. As compared with the other species which have been described it is a decidedly rare mineral. The massive mineral shows a distinct cleavage in one plane, the crystallographic direction of which could not be ascertained in the crystals owing to their small size.

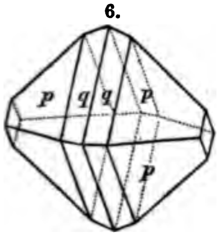
The hardness is 3–3·5; and the specific gravity for the mineral analyzed, containing 12 p. c. quartz is 3·04; this gives on calculation for the pure mineral 3·102. The luster is vitreous to sub-resinous; the color of the perfectly unaltered mineral

* This Journal, III, xiii, June, 1877.

pale rose-pink to yellowish-white, sometimes with a tinge of brown; crystals are occasionally coated dark reddish-brown from surface alteration; the streak is white. Transparent to translucent; fracture uneven; brittle.

Crystalline form.—The crystals of reddingite are rare and occur only in cavities in the massive mineral. They have uniformly an octahedral habit; sometimes only the unit pyramid is present and in other cases a second macrodiagonal pyramid, with the brachypinacoid as shown in the accompanying figure. The crystals belong to the ORTHORHOMBIC SYSTEM. The fundamental angles are as follows:—

6.



$p \wedge p''$,	$111 \wedge \bar{1}11$	=	76° 50′
$p \wedge p'''$,	$111 \wedge \bar{1}\bar{1}1$	=	110° 43′

These angles are only tolerably exact, the probable error being as high as ± 5′. The axial ratio calculated from the above angles is:—

c (vert.)	$\bar{b}$	$\breve{a}$
1·0930	1·1524	1·0000

The angles of the fundamental prism (not observed), are $I \wedge I = 98° 6'$ and 81° 54′. The observed planes are:—

b,	i-$\breve{i}$,	010;
p,	1,	111;
q,	1-$\bar{2}$,	212.

The important angles are as follows, calculated from the axial ratio:—

$p \wedge p'$,	$111 \wedge \bar{1}11$.	=	65° 16′
$p \wedge p''$,	$111 \wedge \bar{1}11$,	=	76° 50′
$p \wedge p'''$,	$111 \wedge \bar{1}\bar{1}1$,	=	110° 43′
$q \wedge q'$,	$212 \wedge 2\bar{1}2$,	=	35° 30′
$q \wedge q''$,	$212 \wedge \bar{2}12$,	=	89° 17′
$q \wedge q'''$,	$212 \wedge \bar{2}\bar{1}2$,	=	99° 59′
$b \wedge p$,	$010 \wedge 111$,	=	57° 22′
$b \wedge q$,	$010 \wedge 212$,	=	72° 15′

Of the above angles the only ones that admitted of exact measurement were the three pyramidal angles, of which two have been taken as the basis of calculation and the third gave $111 \wedge 1\bar{1}1 = 65° 22$, required 65° 16′.

Reddingite is closely isomorphous with scorodite and strengite; the corresponding pyramidal angles for the three species are as follows:—

		Reddingite.	Scorodite. (vom Rath.)	Strengite. (Nies.)
$111 \wedge \bar{1}11$	=	76° 50′	77° 8′	78° 22′
$111 \wedge 1\bar{1}1$	=	65° 16′	65° 20′	64° 24′
$111 \wedge \bar{1}\bar{1}1$	=	110° 43′	111° 6′	111° 30′

The axial ratios of the three species are as follow:—

	c (vert.)	$\bar{b}$	$\breve{a}$
Reddingite	1·0930	1·1524	1·
Scorodite (vom Rath)	1·1020	1·1530	1·
Strengite (Nies)	1·1224	1·1855	1·

The relations of the three species in chemical composition are spoken of in a later paragraph.

Chemical composition.—The best available material was used in the analyses by Mr. Horace L. Wells; it was free from every impurity with the exception of the quartz, which was so intimately intermixed that separation was impossible. The presence of the quartz, however, did not interfere in the least with the accuracy of the composition finally deduced. The water was determined directly.

Two analyses gave:

	I.	II.	Mean.
Quartz	12·09	12·07	12·08
P_2O_5	30·17	30·56	30·37
MnO	40·85	40·58	40·71
FeO	4·88	4·70	4·79
Na_2O (trace Li_2O)	·32	0·23	0·27
CaO	0·70	0·64	0·68
H_2O	11·70	11·33	11·51
	100·71	100·11	100·41

Excluding quartz, the mean of the two above analyses gives:

P_2O_5	34·52	·243	·243	1·
MnO	46·29	·652		
FeO	5·43	·075	·746	3·07
Na_2O (tr. Li_2O)	0·31	·005		
CaO	0·78	·014		
H_2O	13·08	·727	·727	3·00
	100·41			

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : 3$, corresponds to the formula $Mn_3P_2O_8 + 3aq$, which requires the following percentage composition:—

P_2O_5	=	34·72
MnO	=	52·08
H_2O	=	13 20
		100·00

It is interesting to note here that the same formula was deduced by M. Debray* for an artificial salt which he obtained in brilliant crystalline grains by boiling a solution of phos-

* Annales de Chimie et de Physique, III, lxi, 433, 1861.

phoric acid in excess with pure magnanese carbonate. He gives, however, no description of the form of the crystals obtained.

The close correspondence of reddingite with scorodite and strengite has already been pointed out; chemically the relation is not so close, for the manganese is all in the lowest state of oxidation and only three molecules of water are present. The formulas for the three minerals are as follows:—

Reddingite	$Mn_3P_2O_8+3aq.$
Scorodite	$FeAs_2O_8+4aq.$
Strengite	$FeP_2O_8+4aq.$

Pyrognostics.—On heating in the closed tube, whitens at first, then turns yellow and finally brown, but does not become magnetic. In the forceps fuses in the naked lamp flame (F=2). B.B. colors the flame pale green and fuses easily to a blackish-brown non-magnetic globule. Dissolves in the fluxes and reacts for manganese and iron. Soluble in hydrochloric and nitric acids.

Reddingite is named from the town in which the locality is situated. It was the last of the above species to be discovered, and we were led to make an especial search for it by finding black octahedrons implanted upon one specimen which were obviously pseudomorphs and which could not be referred to any known species. Another specimen exhibited pseudomorphs of the same species, but where the alteration was not so far advanced.

Concluding note.

In a second paper upon this locality which we expect to publish within a few months we shall describe under the name of *fairfieldite* a sixth new species, whose character has been determined too late to find a place in these pages. It is a hydrous phosphate of manganese and lime, having the formula $R_3P_2O_8+2H_2O$, where the protoxide elements are manganese and lime chiefly; also iron and soda in small quantities. Fairfieldite is a yellowish-white to colorless transparent mineral, with an adamantine luster on the surface of eminent cleavage; the hardness is 3·5, and the specific gravity is 3·15

We intend also to give descriptions and, so far as possible, analyses of the other associated minerals, as, rhodochrosite, hebronite, the black massive products of decomposition and other species of special interest.

ART. XII.—*Observations of the Transit of Mercury, May 5–6, 1878*; by L. TROUVELOT.

THE transit of Mercury over the Sun was observed at my Physical Observatory in Cambridge with the 6⅛ inch refracting telescope by Merz, the full aperture being used during the whole time of transit. The power employed for the observations of contacts was 153, but for physical observations higher powers were found necessary. Even as high as 250 and 450 were found excellent during the afternoon. The chronometer was compared before and after transit with the Harvard College Observatory mean time clock.

On the morning of the transit the prospects for good observations were not promising, the sky being overcast with dense and continuous cirri which, however, allowed the sun to be seen through them most of the time. But in consequence of this state of the atmosphere the telescopic image appeared rather poorly illuminated; although, considering the circumstances the definition was fair and the image quite steady, the sun's limb appearing only a little diffused.

Half an hour before the predicted time for contact the sun's surface was carefully scrutinized, but no spots were seen; and although a few small scattered faculæ were visible later, none could be seen at the time, owing probably to the thick vapors in the sky. No trace of the granulations of the solar surface could be seen. The sky forming the background to the sun appeared of a milky whiteness, a very unfavorable condition for the observation of Mercury before ingress.

From $22^h\ 20^m$ till the time of contact, efforts were made to find the planet outside of the sun, but with no success; although the telescope was directed exactly where Mercury entered the solar limb, and my sight must very likely have been directed several times where the visible planet was situated. At $22^h\ 26^m$, the chronometer's beats began to be counted, and at $22^h\ 28^m\ 37^s{\cdot}5$, Harvard College Observatory mean time, the planet suddenly made its appearance, notching the sun's limb almost exactly where my sight was directed at this moment. The suddenness of the phenomenon created some confusion in my mind from which ensued a delay of perhaps one or one and a half seconds in my record of the time, so that most probably the true contact really occurred at $22^h\ 28^m\ 36^s{\cdot}0$, H. C. O. mean time.

Although the contact seemed to me at first to have been instantaneous, yet, some unexplained phenomenon must have taken place immediately before I saw the black notch on the sun's limb, as I distinctly remembered afterwards that my attention

was called to this particular spot by a something I cannot well define, but which made me aware of the approach of the planet. But the impression was so rapidly followed by the contact that I have no definite idea of it, and am consequently unable to describe it.

While the disc of Mercury was passing the Sun's limb, my attention was particularly directed to the observations of the physical phenomena. The luminous point on the disc and the luminous ring were eagerly sought for, but no trace of either of these phenomena was perceived. The two opposite parts of the sun's limb in apparent contact with the black disc of the planet were also carefully observed to see whether there would be any index of atmospheric refraction, but nothing indicating it was observed. It is true that at this time the vapors in our atmosphere were quite dense and the telescopic image faintly illuminated; in fact, the conditions were not at all favorable for such delicate observations.

As the time of internal contact was nearing, it became obvious to me that it would be very difficult to estimate the exact time of true contact by the observation of the breaking up of the cusps, as they did then appear very dark and indistinct, so I immediately concluded to observe the apparent contact when the black disc of Mercury would be in apparent contact with the sun's limb. This was done, and the phenomenon took place at $22^h\ 30^m\ 52^s{\cdot}5$, H. C. O. m. t.

I feel quite confident that I have recorded this internal contact within a second or two of its true occurrence. According to these observations, the time elapsing between the two contacts was $2^m\ 16^s{\cdot}5$. At least a minute passed before I was certain of seeing a thread of light separating Mercury from the sun's limb. No ligament or black drop was seen, however, the dark appearance of the cusps and the considerable time elapsing between the apparent internal contact and the breaking up of the cusps would perhaps indicate that such a phenomenon took place; but if such was the case, the black drop could not have been as dark as the disc itself, otherwise it is likely that it would have been noticed, as I was in expectation of seeing such a phenomenon.

A few minutes after the internal contact, the disc of Mercury appeared pyriform and slightly elongated towards the sun's limb. This decided appearance of the planet continued visible for fifteen or twenty minutes; the major axis of the ellipsis being directed from northwest to southeast, it being a little inclined towards the east to the south of the path of Mercury on the Sun. This appearance was probably illusory, as later when the atmosphere was clear, the black disc appeared perfectly circular.

From the time of first contact till one o'clock in the afternoon, the sky became more and more cloudy and the observations consequently more difficult. During this time no traces of the inter-mercurial planets, or of the luminous ring were seen. However, I had a persistant impression of a faint nebulous cloud on or near the center of the black disc, but notwithstanding my efforts, I was not able to satisfy myself whether it was real or illusory.

At about three o'clock the sky cleared up, the definition was good; small faculæ and the granulations being well seen on the sun, Mercury was observed with much attention. At this time the planet appeared of an intense bluish-black color, much darker than in the morning. With the powers 250 and 450, the planet lost entirely the flat appearance of a disc, and its globular form became very conspicuous and striking; although no difference in the uniformity of its intense bluish-black tint was noticeable which could produce this phenemenon. The blackness of the disc appeared much more intense than the umbra or nucleus of any solar spot I have ever observed, and I do not think that any observer familiar with the appearance of sun spots, could for a moment be mistaken and take a round black spot for a planet in transit, so striking is the difference in character.

The small nebulous cloud observed in the morning on Mercury still appeared to be there in the afternoon, but while the vision had greatly improved by the clear sky, it seemed just as faint, ill defined and ghost-like as when the sky was vaporous. Great efforts were made to see a definite luminous point in this cloud, but nothing of the sort was visible. I was not able to convince myself of the reality of the phenomenon, and I am rather inclined to think it illusory from the well ascertained fact that the nebulous cloud was best seen in the afternoon when the image was slightly tremulous; but the moment it became steady, the phantom cloud vanished entirely, and the disc of Mercury appeared of a uniform intense bluish-black color.

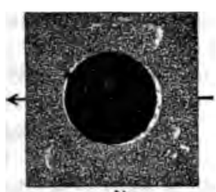
During the whole time of transit, attention was given to the supposed inter mercurial planets which might have been in transit on the sun with Mercury, but no trace of such bodies could be detected, either by direct vision in the telescope or by projection on a screen. If such bodies do really exist and one or several were in transit with Mercury, their apparent diameter must be very small, and at least less than one-half of that of the smallest solar granules, as a black object of this size could have been easily detected during the afternoon.

Although pretty well defined, the edge of the black disc of Mercury never appeared very sharp, even during the moments of best definition; nor did its outline appear perfectly smooth,

but irregularly and slightly serrated, either by black or grayish points. This was particularly noticeable on the south preceding side, where the black disk seemed to be prolonged by a short grayish appendage. This peculiarity already observed in the morning soon after the first internal contact, was still visible during the afternoon when the sky was clear and the image steady; although it was not then so apparent.

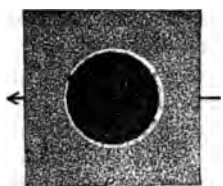
A sharp watch was kept for the luminous ring, and I had almost lost all hope of seeing it, when soon after the sky cleared up, I saw a short and narrow arc of light hanging on the preceding side of the black disc, and a little larger and wider one on the following side. As a few small faculæ were scattered in the vicinity of the planet, I at first thought that Mercury was passing over some of these objects, but it soon became evident that these luminous arcs were really hanging to the dark disc, as I could soon see them passing over the solar granulations with the planet. Fig. 1.

1.



N

2.



N

The seeing having improved soon after, I distinctly saw a continuous ring of light encircling Mercury, and I continued to see the phenomenon for two hours longer, until the sky clouded up after five o'clock. I have not the least doubt as to the reality of the phenomenon, as it was well seen and carefully observed. During the most favorable moments it was very obvious that the ring had not the same degree of brightness throughout, the brighter parts being well defined on the sun, while the others were diffused. Taken as a whole, the ring appeared brighter than the surface of the sun, and for intensity it might have been compared to the narrow and faint faculæ sometimes seen at some distance from the sun's limb. It seemed to me that if instead of having been on the granulations, the planet had been projected over some brilliant faculæ, by contrast, it would have appeared surrounded by a grayish instead of a luminous ring. The outer edge of the ring did not appear sharply defined, except at its brightest parts, but its inner edge was much more apparent, and the irregularities of the black disc very visible on this luminous background.

The ring did not appear perfectly concentric with the black

disc, and this became very apparent a little before five o'clock when the seeing was at its best. Then it certainly appeared narrower on the preceding side than on the following. At this moment I estimated its width on the preceding side at about one-twentieth of the diameter of the disc, while on the following it was estimated at about one-fifteenth. Fig. 2.

Between four and five o'clock, Mercury was spectroscopically observed with an excellent diffraction grating which I owe to the kindness of Mr. Rutherfurd. The spectrum appeared of an intense black color, much darker than any of the absorption lines of the solar spectrum, and quite sharply defined on its edges. I attentively observed whether the absorption lines appeared thickened or deflected close to their point of contact with the spectrum of Mercury, but nothing was seen. I do not remember having seen the spectrum of the luminous ring forming a bright band on either side of the black spectrum, but unfortunately the thought of making this observation did not occur to me till after the transit was over. Judging from the bright appearance of the ring, it is quite likely that this spectrum would have been visible with a spectroscope of small dispersive power.

After five o'clock the sky became partly cloudy, and observations were difficult. At $5^h\ 54^m$ the definition was rather bad, the image being unsteady and the limb of the sun wavey and boiling. A minute or two before the third contact, the sun disappeared behind a narrow, but opaque cloud, and when it emerged from it, internal contact had taken place and was consequently lost, the planet having then about half of its disc engaged on the sun's limb. While Mercury was thus passing over the limb, I easily and very distinctly saw that the two angles formed by the limb of the sun in apparent contact with Mercury had their corners rounded off. Fig. 3. This phenomenon which was very apparent seems to be of the same nature as the black drop, which I had not the good fortune to see. I do not remember having seen at this time any trace of the luminous ring either on, or outside the sun, but the seeing was bad at this moment, and my attention was so much occupied with the last contact that very likely it has escaped my notice.

3.

As already stated, the sun's limb was wavey and boiling at the time of the two last contacts; it is undoubtedly owing to this fact that at $6^h\ 0^m\ 14^s$, Mercury completely disappeared from the limb of the sun, and last contact was recorded. However, a few seconds later, the planet reappeared and was seen still notching the sun's limb, it having probably been lost in the

trough of some deep wave of the sun's edge. The last contact occurred at $6^h\ 0^m\ 36^s.7$, Harvard Coll. Observatory mean time. No trace of the planet was seen after it left the limb of the sun, but the sky was not very clear and the image was too unsteady to make delicate observations.

The luminous ring observed around Mercury in transit has generally been attributed to the horizontal refraction undergone by the rays of the sun in passing through the dense atmosphere which is supposed to envelop this planet. This explanation seems quite plausible, although it is difficult perhaps to conceive how atmospheric refraction alone can produce such a phenomenon, and it would seem that something else is wanting to fully explain it. Perhaps the refraction theory might somewhat be helped by the fact that the sun, having a vastly greater diameter than Mercury, must necessarily illuminate at all times more than one-half of the globe of this planet, and this surplus of illumination must be visible from the earth during transits, and appear as a thin luminous ring surrounding Mercury. Of course the distance between the sun and Mercury considerably reduces the apparent breadth of this ring; but still it is there; and this, combined with the horizontal refraction, may explain the observed phenomena.

Cambridge, May 8th, 1878.

ART. XIII.—*Discovery of a new Planet;* by Professor C. H. F. PETERS.—From a letter to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., July 3, 1878.

ON June 18th I marked upon my chart, quite near to a star of the 11th magnitude, another of the 12th or 13th magnitude; and on June 19th this star was no more in its place. I therefore drew upon the chart all the small stars in the neighborhood; but before the one among these that had revealed itself by its motion as a planet, could be recognized, the sky had become thick. On the following evening, June 20th, there was no difficulty in finding the planet. Its position was put down on the chart; but when the micrometer was arranged for observation, it had clouded up. So the sky remained until June 25th, when a complete determination of its position was obtained. Having notified Professor Pickering, I have received through his kindness also an observation of the same evening, made by Mr. Winslow Upton at the Cambridge observatory.

The following are the positions of the new planet, I have succeeded in gathering here, including those graphically obtained from the chart.

1878.	Ham. Coll. m. t.	[188] apparent. α	δ	
	h. m.	h. m. s.		
June 18,	10 30 —	15 40 28	−17° 5′·41″	Uncertainty ±10″
19,	11 0 —	15 39 56	16 59·1	±30″
20,	10 30 —	15 39 29	16 52·3	±30″
25,	12 23 4	15 37 23·01	16 22 51·0	18 comp. by ring micr.
27,	11 9 54	15 36 45·74	16 12 9·8	16 " "
28,	10 45 49	15 36 29·20	16 6 52·4	9 comp. by filar micr.
29,	10 11 32	15 36 14·82	16 2 ,5.4	10 " "
30,	10 12 48	15 36 1·56	15 57 8·3	12 comp. by ring micr.
July 1,	10 28 13	15 35 50·10	−15 52 23·5	12 " "

The comparison stars of June 28 and 30 require a re-determination by some meridian circle.

ART. XIV.—*On "Indurated Bitumen" in cavities in the trap of the Connecticut valley.* From the Report on the Geology of Connecticut, by Dr. J. G. PERCIVAL.

DR. PERCIVAL'S observations on the occurrence of what he called "indurated bitumen" in the trap of Connecticut valley, given in his Geological Report of Connecticut (1842) are briefly mentioned in Mr. I. C. Russell's paper, page 112 of this volume. Percival's notes are so full, and of so great interest, that we cite further from his Report.

Speaking, p. 315, of the common-variety of amygdaloid accompanying the trap he says, that the "pores" [cavities] are sometimes occupied by a shining black indurated bitumen, somewhat resembling anthracite in appearance." Further, p. 318, that the metallic *veins* in the trap, whose ores are sulphides of copper, lead, zinc and iron, in a matrix of "sulphate of barytes, quartz and calcareous spar," "occasionally contain seams or nodules of indurated bitumen, similar to that already noticed" on p. 318, and that in the "altered rocks adjoining the trap"—the sandstone—various minerals are often found, including "hyalite, epidote, chlorite, brown spar, fluor spar and indurated bitumen." Again, p. 320, he remarks that in the trap region of Berlin and Hartford, there are in the shale *apparent* dikes that consist of indurated shale, "through which points of bitumen are disseminated, as already noticed in a variety of amygdaloid;" and that in the brown and bituminous shale accompanying these dikes, there are "also included seams of bitumen with brown spar and sometimes with fluor."

The above are general statements as to the different modes of occurrence of the "indurated bitumen." In the course of the following pages he mentions the facts at special localities.

On page 376, he observes that east of Farmington near the north point of a ridge of amygdaloid, "a quantity of indurated bitumen (considered as coal) was found on the back of the amygdaloid, the pores [amygdaloidal cavities] of which in the vicinity

were occupied partly by a similar bitumen, and partly by a dark green chlorite." "Copper has been found in veins in the anterior amygdaloidal ridge west of the Hanging Hills," near Meriden, and "a similar bitumen is found in the matrix of the veins, which consists of quartz, calcareous spar and sulphate of barytes."

Page 382. In the trap range west of Middletown "where the stream (the Mattabesick) crosses the third (Eastern) ridge, considerable quantities of indurated bitumen have been found in the trap, occupying veins and the cavities of large quartz geodes"; and farther north, on the east side of the same ridge, where the trap appears as a dike and is bordered laterally by brown indurated shale small veins occur" in the trap and shale containing sulphurets of lead, zinc and iron, in a matrix of quartz, sulphate of barytes and calc spar, and also including seams of indurated bitumen. On page 384 he observes that in the line of the ridge passing through New Britain, at Hart's Mills, there is a wide bed of bituminous shale with interposed bands of a bluish compact subbituminous limestone," and here there is a dike of indurated clay with disseminated bitumen, "adjoining which the shale abounds in cross seams of brown spar with bitumen and fluor."

Page 385. Near the north point of Farmington Mountain west of north from New Britain, the amygdaloid "abounds in agates and has its pores partly occupied by indurated bitumen."

The localities above mentioned are within twenty-five miles of New Haven, to the northeast and north.

Page 388. South of Hartford, toward the southern end of the trap ridge called Rocky Hill, where it is nearly east and west in course, it "crosses a wide valley in which is a large bed of bituminous shale containing fish impressions, recently excavated for coal." The ridge terminates toward the north in low swells of amygdaloid; and just northeast is a mass of dark greenish indurated shale, highly contorted and disturbed in dip, with seams of bitumen and calcareous spar and traces of copper.

After speaking in several places, on pages 428 to 447, of outcrops of bituminous shale and limestone, forming part of the Triassic sandstone formation, and often containing fish remains, he mentions on page 451 the occurrence of similar bituminous shale and limestone in the small Triassic area of Southbury (which is quite independent of that of the Connecticut valley, and fifteen miles west of it); and adds that "seams of indurated bitumen and also of *mineral caoutchouc* occur in the bituminous shale and limestone, and the latter, particularly, is sometimes impregnated with *naphtha*."

Percival's facts thus have great importance toward settling the question as to the origin of the hydrocarbon of the amygdaloid. They show that the material occurs in the Triassic rocks as naphtha; as a flexible half-indurated material which he called caoutchouc; and as a firm, brittle coal-like material, which he calls indurated bitumen. Professor C. U. Shepard, his associate in the survey of Connecticut, mentions the "indurated bitumen" (Rep.

1837, p. 61, 62 and 152); but calls the mineral from the West Hartford trap, anthracite. He remarks that the coaly substance from "the trap at Farmington, Southbury and Rocky Hill, Hartford, ignites slowly and burns without odor; further that the same from the shale at Berlin, and the bituminous shales of Southbury, is "compact bitumen"; that "in many instances when freshly taken from the quarry it is semi-fluid, or only so much inspissated as to form what is called elastic bitumen or mineral caoutchouc, and burns with a white flame and much smoke."

Percival recognized the igneous origin of the trap, and the fact that the Triassic or "Secondary formations were formed from the debris of the Primary rocks." The remark with which he closes the subject implies that he supposed the bituminous material to have come from the same deep-seated source as the trap. Yet his facts, and his special presentation of them, are so well calculated to prove that the bituminous shale and limestone are the sources of this "indurated bitumen," and that the trap, while on its way to the surface, took in the gaseous hydrocarbon distilled from the rocks by the heat—nearly at the same time that it took in moisture in vapor from some sources of water and so became hydrated and vesicular—(a view I have for some years held*), that it is reasonable to suspect that Percival may have entertained this opinion although it was not his final conclusion. It seems hardly probable that, after observing with so much detail the wide distribution of the bituminous shales and limestone, he should have attributed all the impregnating hydrocarbon of these rocks to the igneous eruptions.

The view that the bituminous material in the trap came from the shales and limestone and was taken in by the hot trap on its way through these rocks, is brought out by Mr. G. W. Hawes in this Journal, on page 56 of volume ix, 1875. J. D. D.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Underground Temperatures.*—The subject of underground temperature is daily receiving more attention. Sir William Thomson, in the *Phil. Mag.* for May, 1878, No. 32, page 370, proposes the following problems for solution:

Problem I. A fire is lighted on a small portion of an uninterrupted plane boundary of a mass of rock, of the precise quality of that of Calton Hill, and after burning for a certain time is removed, the whole plane area of rock being then freely exposed to

* This water I have supposed to have largely underlaid the Triassic formation, occupying spaces between it and the subjacent metamorphic rocks, and also to have existed in and among the strata of the formation—the beds being often porous sandstones and loosely united (this Journal, vi, 1873, page 108); and if mainly from beneath the Triassic, it would have been taken in just before the hydrocarbon vapors.

the atmosphere. It is required to determine the consequent conduction of heat through the interior.

Problem II. It is required to trace the effect of an unusually hot day on the internal temperature of such a mass of rock.

Problem III. It is required to trace the secular effect consequent on a sudden alteration of mean temperature.

Problem IV. It is required to determine the change of temperature within a ball of the rock, consequent upon suddenly removing it from a fluid of one constant temperature and plunging it into a fluid maintained at another constant temperature.

Thomson confines himself mainly to the mathematical discussion of problem I, since the solution for problem I can be applied with slight variations to problem II and III, and problem IV is an example of Fourier's well known solution for a globe, which has lately been treated in detail by Professors Ayrton and Perry.

Problem I is thus stated according to the author's assumptions: "*An infinitely small area of an infinite plane, terminating on one side a mass of uniform trap rock, which extends up indefinitely in all directions on the other side, is infinitely heated for an infinitely short time, and the whole surface is instantly and forever after maintained at a constant temperature. It is required to determine the consequent internal variations of temperature.*"

From the mathematical expression obtained from this statement the following conclusions result.

(1) The simultaneous temperatures at different points equidistant from the position of the fire are simply proportional to the distances of these points from the plane surfaces.

(2) The law of variation of temperature with distance in any one line from the place where the fire was applied, is the same at all times.

(3) The law of variation of temperature with time is the same at all points of the solid.

(4) Corresponding distances in the law of variation with distance increase in proportion to the square root of the time from the application and removal of the fire; and therefore, of course, corresponding times in the law of variation with time are proportional to the squares of the distances.

(5) The maximum value of the temperature, in the law of variation with distance, diminishes inversely as the square of the increasing time.

(6) The maximum value of the temperature in the law of variation with time, at any one point of the rock, is inversely as the fourth power of the distance from the place where the fire was applied.

(7) At any one time subsequent to the application of the fire, the temperature increases in any one direction from the place where the fire was applied to a maximum at a distance equal to $\sqrt{2kt}$, and beyond that falls to zero at an infinite distance in every direction. The value of k for the trap rock of Calton Hill

being 141, when a year is taken as the unit of time, and a British foot the unit of space, the radius of the hemispherical surface of maximum temperature is therefore $16{\cdot}8 \times \sqrt{t}$ feet. Thus at the end of one year it is 16·8 feet, at the end of 10,000 years it is 1689 feet, from the origin.

(8) At any point at a finite distance within the solid (which, by hypothesis, is at temperature zero at the instant when the fire is applied and removed), the temperature increases to a maximum at a certain time, and then diminishes to zero again after an infinite time; the ultimate law of diminution being inversely as the square root of the fifth power of the time. The time when the maximum temperature is acquired at a distance r from the place where the fire was applied, is $\frac{t^2}{10k}$, or, according to the value found for trap rock, $\frac{t^2}{237{\cdot}5}$ of a year. Thus it appears that at one French foot from the place of the fire, the maximum temperature is acquired a day and a half (more exactly 1·54 days) after the application and removal of the fire. At 15·4 French feet from the fire, the maximum temperature is reached just a year from the beginning, and at 1540 feet the maximum is reached in 10,000 years.

Many observations on underground temperatures have been made by Dr. Schwartz in the mining district of Schemnitz in Hungary. A resumé of his work has appeared in Nature, April 11, 1878. Observations were taken by the means of mercurial thermometers, placed in holes ·422 and ·79 of a metre, which were bored in the rock of thirty-eight galleries. In the final reductions Dr. Schwartz compares the temperature in the deepest galleries of each shaft with the assumed mean annual temperature of the ground at the shaft mouth. He also gives his reasons for believing that the mean temperature one meter deep in the localities in question is 1° C. higher than the mean temperature of the air. From the reduced observations we learn that there was a total increase of 38°·3 C. in 1587 m., which is at the rate of 1° C. in 41·4 m., or 1° F. in 75·5 feet.

The comparison of the deepest observations with the shallowest which was undertaken as a check upon the above, gave a mean of 1° F. in 72·5 feet.

The rock consisted mainly of trachyte and greenstone. From an analysis of the rocks the report appears to indicate important variations in temperature, due to the decomposition of metallic sulphides. Observations have also been taken by the manager of the Boldon Colliery, between Newcastle and Sunderland, in holes bored upward to a distance of ten feet from some of the deepest seams. The thermometer used is characterized as a slow action one—not a self-registering one—and was placed in the bottom of the hole and protected by an air-tight plug. The distance of the thermometer from the surface of the earth was 1365 feet.

This thermometer, thus placed, gave an indication, April 26, of 75°, which was the same for four consecutive weeks. The same thermometer was placed in the same manner in another hole, 1514 feet from the surface of the earth. Observations taken in July and August gave a temperature of 79°. The mean annual temperature at the surface was assumed to be 48°. For the interval of 149 feet between the holes, there was an increase of 4° F. which is at the rate of 1° F. in 37 feet. In the whole depth of 1514 feet from the lower surface to the lower hole we have an increase of 31°, which is at the rate of 1° F. in 49 feet. Late observations in India indicate that the Summer heat influences observations taken even at a depth of sixty feet. J. T.

2. *On the Law of Solid Volumes.*—SCHRÖDER has investigated the question of the volume occupied by elements in the solid state in compounds and has discovered a law which he calls the law of solid volumes and which he enunciates as follows: In every solid compound, the volume in the solid state, i. e., the stere, of one of its elements determines, by means of the forces active during crystallization, the assumption, by all the other elements, of the same solid volume or stere. In other words, one of the elements assimilates to itself all the others. The molecular volume of a compound in the solid state requires as many atoms as is necessary to make the volume of each element an entire multiple of the controlling stere. A solid molecule contains therefore only entire steres of each element contained in it. The solid molecule of zinc contains Zn_3 and of zinc oxide Zn_3O_3, because, both alone and in the oxide three zinc atoms occupy the volume of five steres, the three oxygen atoms occupying the volume of three. In a formula, Schröder indicates the number of steres of an element by an ordinary, and the number of atoms by a sub exponent. A stere-value is marked by a line over it and a volume calculated or observed, by a line beneath it. Thus silver for example, $\overline{Ag^2_1}=2\times 5{\cdot}14=\underline{10{\cdot}28}$; obs. vol. $=\underline{10{\cdot}28}$, means that an atom of silver or 108 grams takes a space of 10·28 cubic centimeters; i. e., twice 5·14 c. c., or two silver steres. For the chloride, iodide and bromide of silver, he gives $\overline{Ag^2_1}Cl^3_1=5\times\overline{5{\cdot}14}=\underline{25{\cdot}70}$; obs. vol. $\underline{25{\cdot}7}$. $\overline{Ag^2_1}Br^4_1=6\times\overline{5{\cdot}14}=\underline{30{\cdot}84}$, the obs. vol. $\overline{Ag^2_1}I^6_1=8\times\overline{5{\cdot}14}=\underline{41{\cdot}12}$, also the obs. vol. In all three, the controlling volume is the silver stere, silver entering as two steres, chlorine as three, bromine as four and iodine as six. The author has applied his law to a large number of chemical compounds and obtains some significant results.—*Ber. Berl. Chem. Ges.*, xi, 1109, May, 1878. G. F. B.

3. *On Flame Temperatures.*—ROSETTI has continued his experiments upon the temperatures of flames and finds that although gas flames are much increased in volume by pressure, the corresponding zones show nearly the same temperatures, the difference being only 20° for a great variation of pressure. The maximum

temperature in a powerful Bunsen burner consuming to one volume of gas 2·2 of air, was 1360°; becoming 1150° when the volumes of gas and air are equal. Using a Bunsen burner closed below, the maximum temperature observed with a mixture of gas and nitrogen was 1240°, when the proportions were 1 of gas to 1½ of N, and with carbon dioxide, 1190°, the proportions being as 1 to ½. A stearin candle flame had a temperature of 940°, a Locatelli lamp of 920°, a petroleum lamp without a chimney 920°, in the luminous and 780° in the smoky portion, with a chimney 1030°, an alcohol lamp 1170° with alcohol of ·912 sp. gr. and 1180° with alcohol of 0·822. Hence the correctness of diluting alcohol for burning.—*Ber. Berl. Chem. Ges.*, xi, 809, April, 1878.

G. F. B.

4. *On the Production of Ozone, Hydrogen peroxide and Persulphuric acid by Electrolysis.*—The inferior volume of oxygen gas set free in the electrolysis of water acidulated with sulphuric acid, at first observed by Faraday, has been noticed by all physicists who have used the voltameter. BERTHELOT has undertaken to measure this loss and to determine its cause. That it is not due to the production of hydrogen dioxide by the electrolytic ozone acting on the water, is shown by the fact that water and ozone do not combine together directly. Nor does the hypothesis that the oxygen splits into ozone and antozone during electrolysis fit the case, since the relation of the active oxygen existing as gas is to that existing in the liquid, so small, only a twentieth part. In one of Berthelot's experiments, there was 2·2 mgrms. active oxygen in the gas collected and 44 mgrms. in the liquid. Moreover, Meidinger has shown that when the sulphuric acid used had a density of 1·4, the amount of oxygen collected may fall to two-thirds of its theoretical value. In Berthelot's experiment, 12·2 c. c. hydrogen was collected in ten minutes, but only 3·6 c. c. of oxygen instead of 6·14. Since the oxidizing body found in the solution occurs only when this is acidulated with sulphuric acid, Berthelot concludes that it is really persulphuric acid; a view which its reactions confirm. Further, oxygen is gradually disengaged from the liquid, reaching in the course of a few hours, the theoretical quantity and even surpassing it. The bearing of these facts upon the use of sulphuric acid in a voltameter, is evident.—*Bull. Soc. Ch.*, II, xxix, 348, Apr. 1878. G. F. B.

5. *On the Polyiodides.*—JOHNSON, who in 1876 discovered potassium triiodide, ordinarily represented as KI_3, has experimented to ascertain whether the more probable formula is not K_2I_6 analogous to HgI_6, and whether one of the potassium atoms cannot be replaced by a univalent metal, or two atoms in two molecules K_4I_{12} by a bivalent one. Silver iodide, potassium iodide and free iodine were dissolved in the proportion to form AgK_3I_{12}. On slow evaporation, potassium silver iodide first separated in crystals, next crystals of potassium triiodide and lastly crystals having the formula AgK_3I_{12}, KI. On repeating the preparation, using the proportions of this formula, only these

crystals separated, having five molecules crystal water. The attempt to produce a thallium compound like the silver one was not successful. With lead by adding to a hot saturated solution of sugar of lead in boiling alcohol, a strong alcoholic solution of potassium triiodide, the liquid deposited on cooling small well formed crystals, square prisms aggregated in clumps, strongly dichroic and permanent in the air. On analysis it gave the remarkable empirical formula $Pb_8C_{36}H_{54}O_{28}K_6I_{17}$. No rational formula for it has yet been obtained.—*Jour. Ch. Soc.*, xxxiii, 183, May, 1878. G. F. B.

6. *On Two new Cyanogen Products, Ponsælion and Cyanone.*—THOMPSON has observed that when coal gas containing a large proportion of CS_2 is passed for some days through a solution of mercuric cyanide in potassium hydrate, a white precipitate is formed, which finally becomes of a beautiful scarlet. To prepare it directly mercuric oxide is boiled with potassium cyanide, adding potassium hydrate in excess, agitating with CS_2 and gently warming. When washed and dried it resembles vermilion in color, but the tint is not as violet. It sublimes to a jet black mass on heating, becoming scarlet again on pulverizing it. It has the empirical formula HgS_2CH, and is attacked only by aqua regia and chlorine. Hydrogen sulphide does not affect its color. The author calls it ponsælion, from *Pons Ælii*, the old name of Newcastle-on-Tyne. The white precipitate, which is at first produced, when collected, washed and dried, is a gray white powder which explodes violently when heated to about 400° F., depositing a substance like soot. It has not been analyzed but appears to be a mixture of two bodies, one containing sulphur the other cyanogen. To the latter the author gives the name cyanone. The mercury may be replaced by copper, forming an equally explosive body. The explosions in brass or copper gas pipes may be due to this copper compound produced by the CS_2 in the gas.—*Ber. Berl. Chem. Ges.*, xi, 517; *Jour. Chem. Soc.*, xxxiii, 404, May, 1878. G. F. B.

7. *On the Atomic Weight of Gallium.*—LECOQ DE BOISBAUDRAN has determined, at least approximately, the atomic weight of gallium by two different methods; i. e., by ignition of ammonio-gallium alum, and by calcination of the nitrate, prepared from a known weight of the metal. The ammonio-gallium alum was prepared with the metal recently obtained by the author in conjunction with Jungfleish. By repeated crystallizations the last traces of zinc and of copper were eliminated. The alum was placed in a tared crucible of platinum and heated to bright redness, 3·1044 grams of alum gave 0·5885 gram of gallium oxide G_2O_3 losing nothing on further heating. From these data the atomic weight is 70·032. For preparing the nitrate, a fragment of gallium was used which came from the previous quantity. No foreign bodies could be detected in it with the spectroscope. It was dissolved in nitric acid containing a little hydrochloric, evaporated, treated with nitric acid, again evaporated, and finally calcined at bright redness, 0·4481 gram of gallium gave 0·60345 of

oxide, from which deducting the impurities in the materials gave 0·6024 gram oxide corresponding to an atomic weight of 69·698. The mean of these two values is 69·865. This value is very near those deduced from the position of gallium in the chemical scale. That deduced from a classification of the elements based on their properties and atomic weights is 69·82; that based on the wave lengths of its lines is 69·86; and Mendelejeff's classification gives it 68.—*Bull. Soc. Ch.*, II, xxix, 385, May, 1878. G. F. B.

8. *On Hexoylene, prepared from Mannite.*—By addition of bromine to hexylene prepared from mannite, and by treating the product so as to separate hydrogen bromide, a monobromhexylene results. Hecht has now observed that by treating this substance with alcoholic potash in closed tubes for 12 hours at 160°–170°, it gives up all its bromine and is converted into hexoylene. On adding water to the distillate from several tubes, two portions separated. The first a yellow liquid which floated on the surface, was hexoylene; the second, which fell to the bottom as a yellow oil was undecomposed monobromhexylene, in amount about one-third of the quantity used. The hexoylene distilled between 80° and 83°, and is a colorless mobile liquid of a penetrating disagreeable odor. It is optically inactive, has a specific gravity of 0·7494 at 0°, does not solidify in a freezing mixture and has the formula C_6H_{10}. It is not attacked by hydrochloric acid, but is dissolved by strong nitric and sulphuric acids. It does not reduce ammoniacal copper or silver solutions. Oxidized with chromic acid it yields acetic and butyric acids. Hence the author gives it the constitutional formula $CH_3—C\equiv C—CH_2—CH_2—CH_3$. The di- and tetra-bromides are described.—*Ber. Berl. Chem. Ges.*, xi, 1050, May, 1878. G. F. B.

9. *On Phytosterin.*—By extracting finely pulverized calabar beans at ordinary temperatures with petroleum ether, Hesse has succeeded in obtaining from them an oil, possessing their odor in a high degree, which on standing became filled with crystalline plates. These recrystallized from hot alcohol, are brilliant white in color and contain crystal-water. But from chloroform, ether or naphtha they separate anhydrous. It is not soluble in water or alkalies, fuses at 132° to 133°, and affords on analysis the formula $C_{26}H_{44}O$. Hesse calls it phytosterin. It was first noticed apparently by Beneke in peas and erroneously called cholesterin. It is optically active and rotates to the left, though less than cholesterin. Assuming that $C_{26}H_{44}O$ is its correct formula, that of cholesterin being $C_{25}H_{42}O$, it would appear to be the next higher homologue of the latter. The author suggests that phytosterin as well as cholesterin may occur in the animal organism. The physiostigmin of Kennedy he regards as phytosterin.—*Liebig's Ann.*, cxcii, 175, May, 1878. G. F. B.

II. Geology and Mineralogy.

1. *On the Geological results of the Polar Expedition under Admiral Sir George Nares, F.R.S.;* by Captain H. W. Feilden, R.A., F.G.S., and C. E. De Rance, Esq., F.G.S.—The authors describe the Laurentian gneiss that occupies so large a tract in Canada as extending into the Polar area, and alike underlying the older Paleozoic rocks of the Parry Archipelago, the Cretaceous and Tertiary plant-bearing beds of Disco Island, and the Oolites and Lias of East Greenland and Spitzbergen. Newer than the Laurentian, but older than the fossiliferous rocks of Upper Silurian age, are the Cape-Rawson beds, forming the coast line between Scoresby Bay and Cape Cresswell, in lat. 82°40′; these strata are unfossiliferous slates and grit dipping at very high angles.

From the fact that Sir John Richardson found these ancient rocks in the Hudson's Bay territory to be directly overlain by limestones, containing corals of the Upper Silurian Niagara and Onondaga group, Sir Roderick Murchison inferred that the Polar area was dry land during the whole of the interval of time occupied by the deposition of strata elsewhere between the Laurentian and the Upper Silurian; and the examination by Mr. Salter, Dr. Haughton and others, of the specimens brought from the Parry Islands have hitherto been considered to support this view. The specimens of rocks and fossils, more than 2,000 in number, brought by the late expedition from Grinnell and Hall Lands have made known to us, with absolute certainty, the occurrence of Lower Silurian species in rocks underlying the Upper Silurian; and as several of these Lower Silurian forms have been noted from the Arctic Archipelago, there can be little doubt that the Lower Silurians are there present also. The extensive areas of dolomite of a creamy color discovered by M'Clintock around the magnetic pole, on the western side of Boothia, in King William's Island, and in Prince of Wales Land, abounding in fossils, described by Dr. Haughton, probably represent the whole of the Silurian era and possibly a portion of the Devonian.

The bases of the Silurians are seen in North Somerset, and consist of finely stratified red sandstone and slate, resting directly on the Laurentian gneiss, resembling that found at Cape Bunny and in the cliffs between Whale and Wolstenholme Sounds. Above these sandstones occur ferruginous limestones, with quartz grains, and still higher in the series the cream-colored limestones come in. The Silurians occupy Prince Albert Land, the central and western portion of North Devon, and the whole of Cornwallis Island. The Carboniferous Limestone was discovered, rising to a height of 2,000 feet, on the extreme north coast of Grinnell Land, in Feilden and Parry Peninsulas, and contains many species of fossils in common with the rocks of the same age in Spitzbergen and the Parry Archipelago, being probably continuously connected

with the limestone of that area, by way of the United States range of mountains. The coal-bearing beds that underlie the Carboniferous Limestones of Melville Island are absent in Grinnell Land, but they are represented by true marine Devonians, established in the Polar area for the first time through the determination of the fossils by Mr. Etheridge. In America a vast area is covered by Cretaceous rocks. The lowest division, the Dakota group, contains lignite seams and numerous plant-remains indicating a temperate flora; overlying the Cretaceous series are various Tertiary beds, each characterized by a special flora, the oldest containing sub-tropical and tropical forms, such as various palms of Eocene type. In the overlying Miocene beds the character of the plants indicates a more temperate climate, and many of the species occur in the Miocene beds of Disco Island, in West Greenland, and a few of them in beds associated with the 30-feet coal seam discovered at Lady Franklin Sound by the late expedition. The warmer Eocene flora is entirely absent in the Arctic area, but the Dakota beds are represented by the "Atane strata" of West Greenland, in which the leaves of dicotyledonous plants first appear. Beneath it, in Greenland, is an older series of Cretaceous plant-bearing beds, indicating a somewhat warmer climate, resembling that experienced in Egypt and the Canary Islands at the present time. In the later Miocene beds of Greenland, Spitzbergen, and the newly discovered beds of Lady Franklin Sound, the plants belong to climatal conditions 30° warmer than at present, the most northern localities marking the coldest conditions. The common fir (*Pinus abies*) was discovered in the Grinnell Land Miocene, as well as the birch, poplar and other trees, which doubtless extended across the polar area to Spitzbergen, where they also occur.

At the present time the coasts of Grinnell Land and Greenland are steadily rising from the sea, beds of glacio-marine origin, with shells of the same species as are now living in Kennedy Channel, extending up the hillsides and valley slopes to a height of 1,000 feet, and reaching a thickness of from 200 to 300 feet. These deposits, which have much in common with the "bowlder-clays" of English geologists, are formed by the deposition of mud and sand carried down by summer torrents and discharged into fiords and arms of the sea, covered with stone and gravel-laden floes, which, melted by the heated and turbid waters, precipitate their freight on the mud below. As the land steadily rises these mud-beds are elevated above the sea. The coast is fringed with the ice-foot, forming a flat terrace 50 to 100 yards in breadth, stretching from the base of the cliffs to the sea-margin. The wall of ice is not made up of frozen sea-water, but of the accumulated autumn snowfall, which, drifting to the beach, is converted into ice where it meets the sea-water which splashes over it.—*Proc. Geol. Soc., London*, April, 1878.

2. *On the Paleontological results of the recent Polar Expedition under Sir George Nares, K.C.B., F.R.S.;* by Captain H. W.

FEILDEN, R.A., F.G.S., and ROBERT ETHERIDGE, Esq., F.R.S., F.G.S.—In this communication the authors brought before the Society the paleontological results and details of the collection made by the naturalists and other officers of the late expedition to the Arctic Circle under Admiral Sir G. Nares. The purpose of the paper was to record the presence of Silurian and Carboniferous fossils in the highest latitude yet reached, 82° 45′ N. Of the former group 60 species have been determined, ranging from the Lower to the Upper Silurian, both Llandeilo and Wenlock types being present and numerous, notably in the class Heteropoda, two species of the genus *Maclurea* and *Bellerophon*, with *Strophodonta* and *Raphistoma*, &c., also the genus *Receptaculites*. Upper Silurian species of Actinozoa belonging to *Halysites*, *Favosites*, *Heliolites*, *Favistella*, *Zaphrentis*, *Amplexus*, *Cyathophyllum*, and *Arachnophyllum* were noticed, and correlated with British forms when possible; but, on the whole, the facies of the Cœlenterata is American rather than European. Among the Crustacea five genera were noticed—*Bronteus*, *Calymene*, *Encrinurus*, and *Proëtus*, all Upper Silurian; and the genus *Asaphus*, associated with *Maclurea*, of Lower Silurian age. Ten species of Brachiopoda belonging to the genera *Pentamerus*, *Rhynchonella*, *Chonetes*, *Atrypa*, *Strophomena* have been determined.

Collections were made from twenty localities, ranging from lat. 79° 34′ to 82° 40′ N., notably the highest at Cape Joseph Henry, where Captain Feilden obtained a numerous Carboniferous-limestone fauna, numbering about thirty species, chiefly Brachiopoda and Polyzoa, all determined species, and American in character rather than British. Mr. Etheridge believed he had determined, through certain forms of Brachiopoda, the presence in a ravine at Dana Bay of the Devonian rock below the Carboniferous Limestone south of Cape Joseph Henry and Feilden Isthmus, the want of plant-remains preventing any correlation with the Ursa stage of Heer. It cannot now be doubted that an extensive Silurian fauna extends to, and is present, from lat. 79° to lat. 82° N., illustrating both the lower and upper divisions of this group of rocks, especially the equivalents of our Wenlock series. Again, north of these there sets in a clearly defined Carboniferous-limestone fauna, reaching the extremity of the highest latitude we know, and probably striking away beneath the Polar sea to Spitzbergen, where the same species have been described by Toula. The authors, through certain fossils, then endeavored to show that on the whole the facies of the Polar Paleozoic fauna was more nearly allied to that of America than to that of Europe, and thus must be correlated with it, although it was shown that a large number of species are common to the two areas, especially the British Islands. The absence of Lamellibranchiata in rocks older than the Tertiary was noticed as having special interest in the physical history of the Polar seas in Paleozoic and Mesozoic times. None have ever been detected in these rocks. The authors stated that they had sought also for evidence of Trias and Permian fossils in

this and other collections made, but there appeared to be none. They also discussed the question of the deposition and extension of the Lias as represented at Eglinton Island and Spitzbergen.—*Ibid.*

3. *Geological Survey of Pennsylvania. Report of Progress in the Beaver River District of the Bituminous Coal-fields of Western Pennsylvania*, by I. C. WHITE. 338 pp., 8vo. Harrisburg, 1878.—The bituminous coal-fields of the district here reported upon are carefully described, their coal-beds, stratification, fire-clays, oil-sands and oil-wells, and other points of geological interest, and illustrated by three geological maps of parts of Beaver, Butler and Allegheny Counties, and twenty-one plates of vertical sections. Mr. White also describes the surface features of the region, including the river valleys, the drift, and the height and constitution of the terraces. Along the Ohio and Big Beaver the terraces are continuous and have the following heights above the river: 1st (lowest being the present flood-plain of the river) 30 to 40 feet; 2d, 60 to 80; 3d, 120 to 130; 4th, 200 to 220; 5th, 280 to 300 feet. The 2d and 3d are wide and consist in part of coarse gravel and cobble stones. The 4th, on the Big Beaver, has at top a deposit of yellowish white unctuous clay. The fifth is seen a few miles below Pittsburgh, and is gravelly near its top.

At New Brighton, the terraces have the following heights above the Big Beaver: 1st, 30 feet; 2d, 80; 3d, 125; 4th, 215 feet. The 2d is a mass of rounded stones, and so also the 3d. The 4th extends up the Beaver for a long distance and is covered throughout with the creamy clay seen at New Brighton. The clay yielded on analysis by Professor Wuth, Silica 51·34, alumina 33·50, iron oxide 0·78, magnesia 0·70, lime 1·85, alkalies 1·11, water 9·80. The clay is stated to be evidently a lake deposit, and probably marks the limit to which the valleys of the Beaver and Ohio were filled with silt during the Champlain Period.

Under the head of ***buried river channels***, Mr. White observes that the bed of bowlders and detritus over which the Ohio flows below the mouth of the Big Beaver has a great depth; that the Ohio must once have flowed certainly 100 feet below its present level, and possibly over 200 feet. He shows that the Beaver Creek for several miles above its mouth does not flow in its old channel; and that this old channel was more than 100 feet deeper than its present bed, an iron rod having been driven down to this depth without reaching rock; and probably it is 200 feet below, since, as stated by Dr. Newberry, the oil-wells bored at the junction of the Mahoning and Shenango, found no rock for 150 feet below their present beds.

The volume commences with a Preface of much interest by Professor Lesley, the director of the survey—the chapter to which he alludes in his communication published on page 68 of this volume. It contains also a description, by Lesquereux, of a ***Fungus*** found on a ***Sigillaria*** in a bed of cannel coal, in Beaver County, Pennsylvania; he names it ***Rhizomorpha Sigillariæ.***

4. *Eruptive copper-bearing rocks of Lake Superior.*—Mr. RAPHAEL PUMPELLY has an elaborate memoir in volume xiii of the Proceedings of the American Academy of Boston, on "the metasomatic development of the copper-bearing rocks of Lake Superior." These rocks are described as heavy (sp. gr. 2·8–3·05), dark brownish black, augitic rocks, without hornblende in any of the varieties, but often chrysolitic. The triclinic feldspar is for the most part labradorite or anorthite, so that the chemical composition is to this extent essentially that of doleryte or a diabase, or a chrysolitic variety of these basic rocks. They are generally more or less altered and consequently chloritic; and they are frequently amygdaloidal--a very common fact with altered or chloritic eruptive rocks. Titanic iron or magnetite and apatite are also among the constituents.

Mr. Pumpelly has sought to determine with the aid of the microscope and by optical methods, the order of succession in the production of the constituent minerals of the rocks, and particularly of the minerals made through the alteration of the original minerals. In this study he has worked with great care, and has reached many interesting results. Not only have several varieties of the eruptive rocks been investigated microscopically, but also the condition of the rock in the vicinity of veins and cavities; the relations of each result of alterations, through various stages, to the mineral from which it sprung and the further successive changes that have taken place; and thereby he has illustrated in different ways the subjects of pseudomorphism as well as the paragenetic relations of the minerals. Among pseudomorphs after the feldspar of the rock he finds besides those of chlorite, also others of prehnite, analcite, quartz and calcite. He mentions also, the occurrence of orthoclase, epidote, chlorite, quartz and calcite as pseudomorphs after prehnite. Among the results of alteration of augite, there are besides chlorite of two or more kinds, hematite, magnetite, calcite, quartz, native copper; and among those of chrysolite, hydrous iron oxide, a green serpentine-like mineral, and hematite.

The following are some of the cases mentioned of the order of succession in the products of alteration of the feldspar:

(1.) Prehnite, chlorite, orthoclase, epidote, quartz.

(2.) Prehnite, chlorite, epidote, quartz, native copper.

(3.) Prehnite, epidote, calcite, quartz.

(4.) Prehnite, chlorite, orthoclase—orthoclase being a product after prehnite.

In the filling of amygdaloidal cavities there have been formed in succession, as pseudomorphs after prehnite, chlorite, calcite, green-earth; in other cases, epidote and calcite.

Mr. Pumpelly's memoir is without plates. But his clear descriptions make them almost unnecessary to one who is at all familiar with the illustrations in the more recent works on lithology.

The name adopted by Mr. Pumpelly for the principal part of the eruptive rocks is *melaphyre*—as defined in the recent work on lithology of Rosenbusch. The name has had almost as many uses as there are writers that have used it, and it would be better if it were banished altogether from science. By optical means, the occurrence of oligoclase and albite, as constituents of some varieties of the "melaphyre" is inferred, and also the presence of some orthoclase. But this application of DesCloizeaux's method of distinguishing the feldspars to the examination of thin slices of such rocks is acknowledged by the author to give doubtful results; in fact, it is of almost no value. The memoir makes little use of chemistry in the determination of the constituent minerals.

5. *Discovery of Rock Salt at Wyoming in Western New York.* --In a communication from Mr. JAMES MACFARLAN to the *Syracuse Journal*, on the 29th of last June, the very important discovery is announced of a bed of rock salt in the Onondaga salt group, New York, (middle of the Upper Silurian). The locality is thirty-seven miles south of Rochester, on the Rochester and State-line Railroad. The boring passed first through 660 feet of shales of the Genesee, Hamilton and Marcellus groups; then 110 feet of hard rock, reported as sandstone or limestone; then 80 feet of hard limestone, when salt water appeared; below this, 380 feet of "hard and soft rock, limestone and shale" belonging to the Corniferous limestone of the Upper Helderberg and the Water-lime, and to the limestones and shales of the upper part of the Onondaga salt-group; next, 1,240 feet down, a layer of soft shales 20 or 30 feet thick was passed through, and then, at a depth of 1,279 feet, the bed of rock salt was struck. It had a thickness of 70 feet; of this, 40 or 50 feet consisted of pure salt, and the rest was more or less mixed with earth; but whether the earthy impurities were owing to the existence of layers of shale, or to fragments of rock carried in by the boring is not ascertained. The boring was continued to a depth of 1,530 feet, through adjacent red shales and red sandstones of the salt group, and the Niagara limestone was reached at 1,562 feet. Dr. Engelhardt, the chemist of the Syracuse salt companies, has visited Wyoming and taken specimens of the rock salt for analysis. It is now proposed to bore on the south side of the Syracuse valley, since there is a prospect of striking the same bed; it would be necessary to carry the boring down only a few hundred feet to settle the question. Success would substitute a mine of rock salt of indefinite extent for weak brines.

6. *Description of the Wilcox Spouting Water-Well;* by CHAS. A. ASHBURNER, M.S., Assistant Geol. Survey, Penn.—The Wilcox Spouting Water-Well for the last nine months has attracted considerable attention, from the immense columns of water and gas which are periodically (every seven minutes) thrown up into air to a height of from 85 to 115 feet. The well is located in the valley of West Clarion Creek, just north of the southern boundary

of McKean County, Pennsylvania, and five miles north of Wilcox, a station on the Philadelphia and Erie Railroad 104 miles east of the City of Erie.

The history of the well may be briefly stated as follows:

The Wilcox Well No. 1, or the old Adams Well, was drilled in 1864 (?) to a depth of 1618 feet and afterward continued to a depth of 1,785 feet,* where the tools which still remain in the hole, were lost.

The elevation of the top of the conductor above the railroad bridge at Wilcox is 120 feet or 1,629 feet above the mean level of the Atlantic Ocean.†

The well was drilled "wet," that is, no effort was made to keep the water encountered in the upper part of the hole from following the drill. Great difficulty was experienced in drilling on account of a heavy water vein which was struck at 60 feet depth. This was more particularly the case after the gas veins at 1200 and 1600 feet respectively were met. The water would flow into the hole on top of the gas which it would confine until the pressure of the latter become so great that a huge column of the water would be thrown out of the hole to the annoyance of the drillers. This occurréd periodically.

After the tools were lost the upper 400 feet of the well was cased with a four inch casing having a water packer or seed bag attached to its lower end, effectually excluding the water and rendering the hole practically dry.‡

The well was then tubed and it is reported that as much as 100 barrels of oil were pumped and shipped to market; but on account of the great expense of procuring the petroleum, the hole was finally abandoned and the gas allowed free escape into the open air. The gas was afterward fired and the derrick burned. Three or four years ago a wooden plug was inserted into the casing, which only permitted a partial escape of the gas.

About the beginning of the year 1876, when Well No. 2 was started 900 feet distant, a pipe connection was made with Well No. 1, and the gas used as fuel in drilling Well No. 2. The surplus gas was conveyed through a U-shaped tube and discharged over a water tank, the water being splashed by the gas over the orifice of the pipe. The pressure of the gas being thus suddenly relieved a ring of ice an inch thick was formed, which remained under the warmest sun. The ice in this case was produced naturally on the same principle that governs the operation of the Kirk freezing machine.

From the time the gas was first struck by the drill up to the latter part of 1876, it seemed to have, according to Mr. Schultz, a constant flow, but as no measurement was made of its pressure it is probable that it gradually diminished.

* Authority, Mr. M. M. Schultz, of Wilcox.

† The elevation of Wilcox being 1,509 feet according to railroad levels made subsequent to 1862.

‡ For a complete record of the Well, see a paper by Prof. Lesley, in the Proceedings of the American Philosophical Society, vol. x, page 238; also one in the Petroleum Monthly of a later date.

A little oil being found in Well No. 2, an inch pipe was inserted at the depth of 2,000 feet (the well being 2,004 deep), and it was proposed to utilize the pressure of the gas to force the oil out of the tubing. The resistance offered to the flow of the gas was so great that after a few hours the gas ceased to flow entirely from both wells, Nos. 1 and 2. After thirty-six hours of inactivity it commenced flowing again with greater energy. In the early part of January, 1877, the pressure of the gas seemed to increase suddenly; but not finding a free passage from Well No. 1, on account of the wooden plug which had been inserted into the casing and which the gas was unable to blow out, the casing was broken at a depth of 175 feet, and the upper portion lifted bodily out of the well. As soon as this occurred the conditions which had existed during the process of drilling were restored, and a column of water was thrown out of the hole every eight minutes to a height of from 80 to 90 feet, and lasting from three to five minutes. This continued until about the middle of May, when the gas from both wells ceased to flow without any obstruction having been knowingly placed in its way.

On the 14th of July, at 1 A. M., the gas made its appearance again and began to throw the water with great energy to a height ranging from 85 to 115 feet; also with a smaller column from three to eight feet high in the intervals between the larger ones; the phenomenon recurring every seven minutes.

During the time that the water columns are thrown out of the well the gas is thoroughly mixed up with the water and is readily ignited. The sight during the flow of the larger column is grand, particularly at night. The water and fire are so promiscuously blended that the two elements seem to be fighting for the mastery.

On July 19th, I closely watched the well for two hours, from 1.19 to 3.22 P. M., and carefully recorded the time of each change in the condition of the water and gas as they spouted from it, noting the number of pulsations in the larger column, and determining its maximum height by triangulation.

By an inspection of the intervals between the recurring phenomena, it is at once seen that there is a marked regularity in the action of the well; in fact, the slight irregularities observed may in a measure be attributed to the personal equation of the observer. In the time included from 10.39 A. M. to 3.15¾ P. M., there were counted 39 of the larger water columns, making the average time between the commencement of each column 6 minutes and 55 seconds.

Occupying every consecutive 7 ± minutes we have the following sequence of events.

The water from the "water vein" at the depth of 60 feet, and from the pool surrounding the top of the conductor flows into the well for 55 seconds, during which time no gas is detected issuing from the hole. At the end of this time the water from the pool ceases to run in, and the gas rises bubble by bubble for 5 seconds.

A column of water and gas now commences rising, makes 6 pulsations, attains a maximum height of 115 feet in 40 seconds, and vanishes in one minute. The water from the pool and water vein immediately flows into the well for the second time, continuing for 1 minute and 30 seconds, during which time no gas flows out. At the end of this time the gas rises bubble by bubble for 40 seconds, when the smaller column of water and gas rises, attaining a maximum height of 5 feet in 10 seconds and vanishes in 1 minute and 10 seconds. The gas still continues to rise but no water flows into the well from the pool for 35 seconds, when the same series of phenomena repeat themselves. Such are the facts.

The explanation of the action may be readily imagined. The pressure of the gas having relieved itself in throwing out of the well the larger column, the water flows into the hole until the pressure of the gas becomes so great again that instead of rising up in small bubbles through the water it rushes out of the well, throwing the water at the same time to a height of from 3 to 8 feet. After the column has vanished the gas continues to rise in great quantities, keeping the water from flowing in from the pool, until the pressure is exhausted. The water now flows into the well till the pressure of the gas in its reservoir has increased to such an extent that it thrusts out of the hole the larger column of water to a height of from 85 to 115 feet.

The smaller column of water is probably produced by the gas coming from the smaller vein at 1200 feet depth, while the larger column is thrown up by the gas coming from the greater vein at a depth of 1600 feet. But, of course, neither the one nor the other column is produced by either of the gas veins exclusively, for the gas must be flowing from both horizons more or less all the time. It will be noticed that more water flows into the hole directly after the larger column has been thrown up, and that the smaller column throws up less water, and *vice versa.*

It was not possible to obtain the pressure or amount of gas coming from the well. The estimated pressure at the time that 175 feet of casing was blown from the well was about 250 pounds to the square inch. It is possible that the accumulated pressure at the time that the larger water columns are thrown up may be as high as 250 pounds; but the constant pressure of the gas if unobstructed by the water would probably not be more than 50 pounds.

The action of the Wilcox well is nothing novel, but the observations are interesting and valuable from the fact that a complete record and history of the well have been preserved, and the accompanying facts add much to what has been recorded of similar wells.

7. *Superficial Geology of British Columbia.*—Mr. George M. Dawson has an interesting paper on this subject in the Quarterly Journal of the Geological Society for February, 1878. He speaks of Bute Inlet, one of the fiords, as a chasm 40 miles long, running into the center of the Coast Range, and surrounded by mountains,

which in some places rise from its border in cliffs and rocky slopes to a height of six to eight thousand feet. The islands about its mouth are *roches moutonnées*, polished and grooved; and one of them, a steep mountain 3,013 feet high, is smoothed to the summit on the north side, while rough to the south. The striation of the Bute inlet region is S. 22° E., or in the direction of the valley. The glaciation over southeastern Vancouver Island is attributed to a great glacier which swept over it from north to south, a glacier that filled the Strait of Georgia, with a breadth in some places of more than 50 miles. The fiords of the northern part of the Strait of Georgia, and to the north, show ice-action to a height exceeding 3,000 feet. In the interior, scratches were observed on the isolated Tsa-whuz Mountain (lat. 53° 40′), 3,240 feet above the sea, whose course was a little west of south. At another place, on the basaltic plateau near Fraser Valley, and 20 miles north of the Chilcotin River, 3,350 feet above the sea, the direction of the scratches was about north-and-south. On Sinter Knoll, north of Gatcho Lake, near the southeastern sources of the Nechaco River, 3,550 feet above the sea, the direction of the grooving was about S. 8° E. South of the Salmon or Dean River, at an altitude of 3,700 feet, the grooving runs S. 37° W. These glacial markings from north to south are attributed by Mr. Dawson to a glacier moving southward. Terraces in British Columbia extend from the sea-level to a height of 5,270 feet.

8. *Geological Survey of Canada.* Report for 1876–1877, ALFRED R. C. SELWYN, Director. 532 pp. 8vo, with several colored maps. 1878.—This volume contains reports by Mr. SELWYN, G. M. DAWSON, J. F. WHITEAVES, JAMES RICHARDSON, T. STERRY HUNT, ROBERT BELL, HENRY G. VENNOR, G. F. MATTHEW, L. W. BAILEY and R. W. ELLS, HUGH FLETCHER, S. H. SCUDDER, B. J. HARRINGTON, and C. HOFFMANN.

Carefully selected graphite from different localities in Buckingham, Canada, afforded Mr. Hoffmann, Carbon 99·675, 97·626, ash 0·147, 1·780, volatile matter 0·178, 0·594; and that from Grenville, Carbon 99·815, 99·757, ash 0·076, 0·135, vol. 0·109, 0·108=100. Ceylon graphite afforded him, Carbon 99·792, 98·817, ash 0·050, 0·283, volatile matter 0·158, 0·900=100. The ash of the Canadian graphite gave, on analysis, 45 to 60 p. c., of silica 8·5 to 11 of alumina, iron sesquioxide 1·230–18·310, manganese sesquioxide 0 to 0·5, with some lime and magnesia, 4 to 7 per cent of potash and soda and traces of copper, nickel and cobalt.

Rensselaerite has been found by Mr. Vennor in the Laurentian rocks of Portage du Fort. An analysis by Mr. Harrington obtained SiO_2 61·33, FeO 0·67, MgO 31·78, CaO trace, water (ign.) 5·85=99·63. Messrs. Bailey and Ells describe with detail the albertite veins and shales of Hillsboro, New Brunswick. They remark that the gypsum beds of Hillsboro have a thickness of 150 feet, and that much of the rock is a pure white alabaster. They are the most extensive and valuable of the plaster deposits of New Brunswick.

The coal-bearing rocks of British Columbia, according to Mr. G. M. Dawson are: 1, Lower Cretaceous (or Cretaceo-Jurassic) on Queen Charlotte Islands, etc., holding anthracite; 2, Cretaceous on Vancouver Island, with bituminous coal; and 3, Tertiary, affording bituminous coal and lignite. The anthracite yielded, on analysis by Dr. Harrington, Fixed Carbon 85·76, 83·09, volatile combustible matter 4·77, 5·02, sulphur 0·89, 1·53, ash 6·69, 8·76= 100. The Vancouver Island coals afford, on an average, Fixed Carbon 64·05, 59·55, vol. 28·19, 32·69, ash 6·29, water 1·47. Trials under the direction of the United States War Department showed that the ratio of coal in weight required to produce the same heat from the Vancouver Island, Bellingham Bay, Seattle coal of Washington territory and Rocky Mountain coal was as 18 : 22 : 24 : 25.

The Tertiary coals include those of Bellingham Bay, and Seattle on Puget Sound. North of the 49th parallel they underlie nearly 1,000 square miles of the low country about the estuary of the Fraser and the lower part of its valley. These coal formations cover great tracts in the interior of British Columbia; and the basaltic outflows of the region form the latest rocks of the lignite-bearing Tertiary. By a rough estimate the number of square miles the formation covers between the 49th and 54th parallels is not less than 12,000. The Quesnel lignitic beds are interesting on account of the plant and insect remains found in them. Some of the insects are described by Mr. Scudder. Mr. Dawson mentions that magnetic iron ore constitutes a bed 20 to 25 feet thick on Texada Island, and has been traced northeast for more than three miles. It rests against a bed of crystalline limestone and partly alternates with it.

9. *Fossil Fishes from the Trias of New Jersey and Connecticut.*—Dr. J. S. Newberry has described (Annals N. Y. Acad., vol. i, no. 4, 1878) the following Triassic fishes: *Diplurus longicaudatus* Newb., *Ptycholepis Marshii* Newb., the former from Boontown, N. J., and the latter from Durham, Conn. As *Ptycholepis* is in Europe a Liassic genus, its occurrence here, as Dr. Newberry states, suggests a query as to the age of the Eastern American Trias. But he observes that other facts show that it does not seriously invalidate the evidence that they are Triassic, though possibly Jurassic in the upper beds. The species is more heterocercal than the European.

10. *Stromatopora.*—At the meeting of the Geological Society of June 5, 1878, a paper by Dr. Dawson of Montreal was read, in which he explained his views as to the Foramineral nature of the Stromatoporidæ—species of which occur in the Lower and Upper Silurian and Devonian, "and are especially abundant in the Trenton, the Niagara and the Carboniferous formations." Professor Duncan remarked, in the discussion which followed, that he believed that different forms were called Stromatopora; that the tubules in the laminæ of some of them had much resemblance to those of Millepora; that they showed no nummuline layer, like

Eozoon, and so he doubted the Foraminiferal character. Dr. Murie stated that some specimens which he had seen resembled the Hexactinellidæ and he thought they represented sponges, though not exactly Hexactinellids.

Mr. H. J. Carter, in the Annals and Magazine of Natual History for July, states that he has found the hexactinellid structure in the Devonian *Stromatopora concentrica.* To observe it, the plane of section must be "tangential to the curve of undulation in the layers of the Stromatopora, or horizontal to its summit." He adds, "It must not be inferred because I have considered this hexactinellid structure 'identical in appearance' with that of Zittel's order Dictyonina" (see a former paper in the Annals, 1877, xx, 416) "that *elementarily* it is so; for in this consists the difference between the hexactenellid structure of *Stromatopora concentrica* and its varieties and that of the vitreous sponges with *octahedral elements* (ibid., xix, pl. 9, f. 11, 12)." "The pores (? calicles) are in the interstices of the hexactinellid structure; but I cannot say more about them than that by their minuteness in *S. concentrica* they appear to have belonged to a Hydroid rather than to an Actinozoic polyp."

11. *On the Section of the Alps, from the valley of Vedro on the south to that of the Rhone on the north along the course of the tunnel of the Simplon;* by M. Renevier.—The rocks encountered, going northward, are: (1) gneiss partly granitoid, having indications in its bedding of a low anticlinal; (2) conformable "crystalline schists," including mica schist, which is partly garnetiferous, chloritic or talcose [? hydromica], gneiss, hornblende slate, with three parallel calcareous bands; (3) the dolomitic band of Gautier; (4) gray shining schists or slates, which are traversed by numerous veins or seams of quartz. These slates have the same steep northwest dip with the dolomitic band; but between the dolomitic band and the crystalline schists there is, according to Renevier, a nearly vertical fault. On the opposite side of the valley of the Gautier the dip is reversed or southeast, and very steep. Following the slates, there are (5) the gypsum and dolomite of the Rhone valley. Nos. 1 and 2 are regarded as the older metamorphic rocks, with probably two or more folds in the region of the "crystalline schists." The gray shining slates toward the north end of the tunnel are without fossils, but are stated to be probably Triassic, or Triassic with Jurassic beds above. They closely resemble those of Mt. Cenis.—*Bull. Soc. Vaudoise der Sci. Nat.*, xv, No. 79. Lausanne, 1878.

12. *Revue de Géologie pour les Années* 1875 *and* 1876; by M. Delesse and M. de Lapparent. xiv, 228 pp. 8vo. Paris, 1878. —This new volume of Delesse and DeLapparent's Annual Review of Geology, like its predecessors, is a very convenient résumé of the principal memoirs on geological subjects for the year. The following facts are cited from it.

The mean height of Europe.—According to a recent estimate from the heights of the surface over Europe by Dr. G. Leipoldt

of Vienna the mean height of the Continent is 296·838 meters, instead of 205 meters as made by Humboldt. The mean heights of the several countries are also given in the "Revue de Géologie."

Temperature of the Earth's crust.—According to M. Ludovic Ville, a deep boring in Algeria, west of Sebkha d'Oran, the temperature of 49°·7 C. was reached at a depth of 578 meters, making the mean increase downward 1° for 7·56 meters. The waters in the boring are very saline. In the Sahara, according to the borings, the increase downward does not increase regularly with the depth; the mean is a temperature of 24° C. at a depth of 60 meters. In Hodna, the temperature is only 22·2° at a depth of 93·8 meters. The region is of much greater altitude than the Sahara, and it is in higher latitude. The mean increase at this place, according to M. Ville, was 1° C. for 23 meters of descent. In the Sahara toward the latitude of Oued Rhir, the increase downward is about 1° for 17·55 meters; showing a diminution toward the south, or with the latitude.

Effect of moisture or dryness in rocks on the facility of crushing.—M. Tournaire, Mining Engineer and M. Michelot have experimented on chalk, dried in a stove (*d*), wet (*i*), and air-dried (*n*) and found that cubes 3 decimeters each way, were crushed, as follows:—when stove-dried it was crushed under 80–92·5 kilograms (mean 86·2); when air-dried, 16·5 to 35 (mean 23·5); when wet, 13·9 to 26 (mean 18·6). M. Delesse gives also the results of various experiments of his own on chalk and the Calcaire Grossier in which he used cubes 5 centimeters each way. Chalk of Issy, when stove dried, was crushed with 36·4 kilograms; when air-dried, 23·6; when wet, 12·9; and the Calcaire Grossier of Vitry (*a*) and St. Denis (*b*) gave the numbers (*a*) 76, (*b*) 48·7; (*a*) 52·8, (*b*) 31·2; (*a*) 26·9, (*b*) 21·8. The results of various other trials with the Calcaire Grossier are given, all confirming the general result here exhibited.

13. *Mémoires sur les Terrains Crétacés et Tertiares, préparé par feu* André Dumont, *edités par* Michel Mourlon, Conservateur au Musée Royale à Histoire Naturelle. Tome 1. *Terrains Crétacés.* 556 pp. 8vo. Brussels, 1878.—The late M. Dumont, the distinguished Belgian geologist, prepared in 1849 a geological map of Belgium. He died in 1857, hardly forty-eight years old, leaving his Reports illustrating the subject in part still in manuscript, and other unfinished work. The Belgian government has recently ordered a new edition of the map, and also the publication of his manuscripts on the Tertiary and Cretaceous formations. Of these, the volume on the Cretaceous formations has just been issued. It is a very valuable contribution to European geology.

14. *Sigillaria lepidodendrifolia* Brgt.—Mr. H. L. Fairchild, in a paper published in the Annals of the New York Academy of Sciences (vol. i, no. 5), gives reasons for believing that the *Sigillaria rhomboidea* (with *S. obliqua*), *S. Brardii*, *S. Menardi*, *S. Serlii*, and *S. Defrancii* of Brongniart and *S. sculpta* of Lesquereux, are identical species with *S. lepidodendrifolia*, and adds that

S. stellata Lsqx. and *S. spinulosa* Germ. may turn out to be the same.

15. *Flora Fossilis Helvetiæ* and *Flora Fossilis Arctica of* OSWALD HEER, Professor of the University of Zurich.—The third part of Professor Heer's Flora Fossilis Helvetiæ has appeared, completing it. This work, which contains 70 plates, is a supplement to Heer's *Flora Tertiaria Helvetiæ*, a work in three volumes with 156 plates. The publishers, J. Wurster & Co., Zurich, have issued also four volumes of *the Flora Fossilis Arctica*, and the fifth is now in the press. The first four volumes of this work contain 214 plates, and the fifth, 44.

16. *Mineralogy and Lithology of New Hampshire*; by GEORGE W. HAWES, Instructor in Mineralogy in the Sheffield Scientific School of Yale College. Part IV, of the third volume of the Geology of New Hampshire, 262 pp. roy. 8vo, with 12 plates. Concord, N. H., 1878.—No part of the publications of the New Hampshire Geological Survey has greater value than this Report by Mr. Hawes on the mineralogy and lithology of the State. The author, besides giving descriptions of external characters and notices of distribution, and of economic uses, in the ordinary style, includes the results of extended microscopic examinations of both minerals and rocks; and many of the most interesting points are illustrated on plates, some of them in colors. The report is therefore an important contribution to the science of lithology. The are some peculiarities in the nomenclature of the rocks; but these do not seriously interfere with the value of the original work. In addition, the author has added, in an introduction to the volume, full details as to the process of slicing minerals or rocks, and explained the method of making microscopic and polariscopic observations on crystals of the several systems. Besides this, he has introduced much information with regard to the distinctions by the same means of the more common minerals. The chromo-lithographic and other plates are beautifully made by E. Crisand of New Haven, Ct., from excellent drawings by the author, and compare well with the best of foreign work of the kind.

17. *American Minerals.*—*Strengite* in crystals has been described by Prof. G. A. König, from Rockbridge Co., Virginia. It occurred in cavities in scorodite. An analysis gave Phosphoric acid 39·30, iron sesquioxide 42·3, water 19·87. The author gives a figure of one of the crystals in his paper in the Proc. Acad. Nat. Sci. Philadelphia, for 1877, p. 277.

Niccolite has been identified by Prof. König among the minerals of "Silver Islet," Lake Superior, associated with galenite, sphalerite and native silver.

Protovermiculite is a vermiculite-like mineral occurring in large grayish-green folia at Magnet Cove, Arkansas, and so named by Prof. König, in the same volume of Proceedings (p. 269): the luster is submetallic, and G. = 2·269. Analysis afforded SiO_2 33·28, $\overline{Al}O_3$ 14·88, $\overline{Fe}O_3$ 6·36, FeO 0·57, MnO *trace*, MgO 21·52,

TiO_2 *trace*, H_2O 3·36, hygroscopic H_2O 20·54 = 100·51, giving the quantivalent ratio for R, $\bar{R}$, Si, 8·735 : 8·842 : 17·738 = 1 : 1 : 2.

18. *Rocks of Quincy south of Boston and Rockport, near Cape Ann, northeast of Boston.*—Mr. M. E. WADSWORTH states that the Quincy syenyte consists chiefly of orthoclase, quartz and hornblende, and that the hornblende is black to dark green in color and included in the quartz; but that there is present some triclinic feldspar and also in some parts disseminated minute crystals of danalite. The stone of the Rockport quarries has been called by most writers syenyte; but Mr. Wadsworth states that at least 65 per cent of it is micaceous and destitute of hornblende, and hence true granite. But while the quarried rock is almost wholly granite, there is some syenyte. The two are so associated that "they are geologically one and the same rock." Besides orthoclase, quartz, and black mica, the last (referred to lepidomelane by Cooke), there are in some parts of the Rockport granite, the minerals cryophyllite and danalite, first announced by Professor Cooke.

19. *On Ionite, a new Mineral;* by S. PURNELL.—In the Pliocene argillaceous lignite of Ione valley, Amador county, California, a peculiar mineral, more or less pure, occurs in thin seams. The specimen examined by me was of what may be called the best quality. It is a firm, earthy, ochreous looking substance of a brownish-yellow color. As it comes from the mine, it contains about 50 per cent of water, but when thoroughly air-dried it readily floats on water, its specific gravity being about ·90. It rapidly re-absorbs water and sinks.

It bears a physical resemblance to the pyropissite of Kengott, found in the lignite of Weissenfels, and like it, melts to a pitch-like mass, which burns easily, with the emission of a dense black smoke having a resinous and aromatic odor, and with a yellow flame. But that it is not pyropissite, or indeed any mineral heretofore described, will, I think, be plain from the examination.

Ionite is not a pure hydrocarbon, as it contains 13 per cent of impurities—principally aluminum silicate. Streak, reddish-yellow; fracture, irregular; luster, none. When pulverized, water dissolves or suspends a portion of the clay in the mineral. Partially soluble in cold alcohol; more so in boiling alcohol, giving a brown solution. Upon the addition of water no precipitate is deposited, but the solution becomes permanently of a milky color, which may be from the presence of paraffine. Very largely soluble in ether, forming a brownish-black solution. Upon adding water a brown, tarry substance is obtained, which is very inflammable, and which, while burning, gives off the odor of burning sealing wax. Completely soluble in chloroform, except the clay or ash, forming a brownish-black solution. Poured into water a brown oil falls to the bottom. Partially soluble in cold, more so in boiling oil of turpentine, forming a wine-red solution. Upon concentration of the solution, crystals of paraffine are separated. Almost entirely insoluble both in cold and boiling petroleum

naphtha; gives a pale red solution. In boiling rectified petroleum, free from naphtha and paraffine, slightly more soluble than in naphtha; gives a pale red solution.

Subjected to dry distillation a brown, tarry oil passes over, mixed with green-colored water. This water is decidedly acid to litmus. At first the oil has a specific gravity less than that of water, but after a few days sinks in the same. This oil and water possesses a very offensive odor, altogether indescribable. The oil is completely soluble in alcohol and oil of turpentine. Tested for paraffine, the oil was proved to contain it, though only in small quantity. I am of the opinion that the amount does not exceed 5 per cent, but this was not determined accurately.

From the examination this mineral may be pronounced an acid hydrocarbon, or fossil cerite, more or less oxidized and more or less impregnated with clay. From its varying solubilities, it is probably a mixture of different hydrocarbon compounds.

As this mineral is found in Ione valley, I would propose to name it from the locality, *Ionite.* To what industrial uses Ionite may be applied, has not yet been investigated, and it is foreign to the purpose of this paper to inquire.—*Mining and Scientific Press*, March 24, 1877.

20. *Cyrstallization of Silica;* P. HAUTEFEUILLE.—If amorphous silica is kept in sodium tungstate at the temperature of fusion of silver, silica crystallizes in minute crystals of the species tridymite. If the temperature is kept long at 1000° C., the tridymite is obtained in thick hexagonal scales. Sp. gr. = 2·30 at 16° C. Tridymite is less permanent than quartz when acted upon by the wet or dry process.

By means of tungstate of soda, amorphous silica or tridymite may be changed to quartz. At a temperature of 750° C., or that just sufficient to hold the tungstate in fusion, the grains of amorphous silica disappear; and after several hundred hours of heating, double hexagonal pyramids of quartz are obtained. Sp. gr. = 2·61 — 2·65. The crystals contain a trace of tungstic acid and 0·003 per cent of soda.

The crystallization is so slow at 750° C., that practically it is necessary to adopt the following method: the silica with the fused tungstate is made to oscillate in temperature many times between 800° and 950°; with the increasing heat the silica combines with the soda, and with the decrease, the silica is precipitated by the tungstic acid. At the commencement of each period of cooling the silica takes the form of tridymite, but as the temperature falls below about 850° C., it takes that of quartz.—*Bull. Soc. Min. de France*, No. 1, p. 1, 1878.

21. *Tridymite.*—M. SCHUSTER has examined the tridymite from an oligoclase-trachyte of Monte Gioino near Tiolo in the Euganean Hills (Northern Italy), and concludes that its crystals are twins under the *triclinic* system, its optical characters affording evidence in favor of this conclusion.—*Min. u. petrogr. Mittheil. herausg. v. G. Tschermak*, Heft 1.

22. *Mineralogical Society of France.*—A mineralogical society was instituted in Paris on the 21st of March of the present year, and the first number of its Bulletin appeared in April. The President of the Society is the eminent mineralogist, M. Des-Cloizeaux; the Vice President, M. Mallard; Secretary, M. Richard; and Treasurer, M. Delesse.

M. Mallard describes, in the first number of the Bulletin, the new mineral *Bravaisite*, from the coal formation of Noyant. It has an argillaceous appearance and is thinly laminated but with a fibrous structure under the microscope. The color is gray, slightly greenish. When moistened, it is almost gum-like, rather than plastic, and strongly unctuous. Fuses easily to a white globule, and is attacked by acids. An analysis afforded SiO_2 51·40, AlO_3 18·90, FeO_3 4·00, CaO 2·00, MgO 3·30, K_2O 6·50, H_2O 13·30=99·40, giving the quantivalent ratio for R, R, Si, H_2, 1 : 3·3 : 9·16 : 3·93; or 1 : 3 : 9 : 4, if the iron is excluded as due to the pyrites present. M. Mallard observes that it is in its composition near pinite, glauconite and carpholite; but nearer a potash zeolite.

23. *Analcite.*—Dr. A. von Lasaulx has examined sections of the picranalcite of Monte Catini, and finds the radiate twinning structure to indicate that the crystals are of the orthorhombic system and analogous to those of phillipsite.—*N. Jahrb. f. Min.*, 1878, p. 510.

III. Botany and Zoology.

1. *Two new Fern-books* are evidences of increasing attention to this beautiful order of plants, both as to botanical study and ornamental cultivation. Perhaps we may in time come to have as copious and popular a fern-literature as that of Great Britain; the crowning work still being the classical one of Professor Eaton, which will take some time to finish. The new-comers are of much less pretension, are handy-books in single 12mo. volumes, of very moderate price, and likely to have a large circulation. The one first published is

Ferns of Kentucky, with sixty full-page etchings and six wood cuts, drawn by the Author, illustrating Structure, Fertilization, Classification, Genera and Species. By John Williamson, Louisville, Ky. Morton & Co. 1878. pp. 154.—The typography is apparently as good as if it were printed in New England instead of Kentucky, where it was not only set up but electrotyped. The illustrations are the author's own etchings on copper, but printed from lithographic transfers, "in every respect as well done as if they had been printed direct." They are anyhow fairly well done, and etching has a certain advantage in exhibiting structure or texture, as the author remarks. The magnified views have probably lost somewhat of expression and sharpness in the transfer. But the gain in cheapness is not to be overlooked. Still the wood-cut figures of the sporangia are much the best, and stand out with refreshing distinctness. A few pages are occupied with the sub-

jects of cultivation, structure and classification. The bulk of the book is devoted to the ferns of Kentucky, and these are treated in a manner to make all plain and clear to amateurs in that State. It serves as well for the adjacent States, which have the same species. We could have helped the author to one more *Asplenium*, viz. *A. parvulum*, which is so abundant in East Tennessee and West Virginia that it cannot fail to inhabit Kentucky. Indeed Mr. Williamson's words in introducing the Ebony Spleenwort give ground for the inference that he, like so many others, has taken *A. parvulum* for a small state of *A. ebeneum*.

Ferns in their Homes and Ours, by JOHN ROBINSON, is the taking title of the second book on this subject. It is published by Cassino of Salem, the publisher of the Ferns of America, to which it becomes a desirable and useful companion. It fills 178 pages, and is illustrated by twenty-two plates, eight of them color-printed representations of species, besides a frontispiece photograph, exhibiting the attractive "Fern-corner" of the author's conservatory. The others represent growth, fertilization and structure of ferns, Fern-cases and jardinieres, out-of-door fernery, pots, pans, baskets, and other appliances, and lastly, a plate supplied by Professor Packard shows up the insects which are pests to cultivated ferns. This work does not describe the species of ferns, but deals with them in a general way, tracing their life-history, discussing their classification and distribution, recounting their principal literature, at least as to the bibliography of the popular and some of the more elaborate works, explains in detail the way to collect them for cultivation, how to establish ferneries and fern-cases, what ferns to grow and where and how, with lists of good species for cultivation, including also Selaginellas, their natural associates. In fact nothing of a practical nature, that we know of, is overlooked, not even the troubling of an out-of-doors fernery by the midnight revels of cats, for which evil an appropriate treatment is prescribed. The book—every way a most attractive one—is so well up to the time, and so full of information, that it even announces, most handsomely, Mr. Williamson's volume, which was published only a fortnight before it. We wish for both books the success they deserve. For the study of species of the middle United States, the Kentucky Manual supplies the want. For general fern-lore and fern-management the Salem work has no rival. The amateur may be happy with either, happier and best provided with both. A. G.

2. T. MACOUN; *Catalogue of the Phænogamous and Cryptogamous Plants (including Lichens) of the Dominion of Canada, south of the Arctic Circle.* Belleville, Ontario. pp. 52. 8vo.—The range takes in British Columbia; the number of species mounts up to 3,081; of the Phænogams to 2,271. It is a naked, numbered list, with no indication of locality or range,—one useful for botanical exchanges, and convenient for other purposes, neatly printed, but not free from typographical oversights. Over 2,900 of the species here enumerated have been collected in their native

wilds by the indefatigable editor. The remarkable accession to the North American Flora which this Catalogue records is that of *Littorella lacustris*. A. G.

3. *The Native Flowers and Ferns of the United States*, edited by Professor Meehan and chromo-lithographed by Prang & Co., evinces its life and good promise of success in the prompt appearing of Parts 3, 4, and 5. Our notice of the first parts is so recent and particular that we need only announce the new ones, which maintain the general character. Botanists may thank the editor for interspersing some figures of plants which the florist and common observer would pass by unnoticed, such as *Carex stricta*, *Cuphea viscosissima*, and *Pedicularis Canadensis*. A. G.

4. *Zoological Distribution, and some of its Difficulties;* by P. L. SCLATER, Esq., M.A., Ph.D., F.R.S.—After pointing out that "locality" is quite as much a part of the proper characters of natural groups of animals as form and structure, the lecturer spoke of "specific" and "generic" areas, and of the doctrine of their continuity. He then treated of "representative species," and showed that, while insular representative species are usually distinct, continental representative species are not unfrequently found to be connected together by intermediate forms. The only hypothesis that would explain these and other phenomena of "distribution" was that of the derivative origin of species. But the question was, were there not exceptional cases of distribution which threw difficulties in the way of the universal adoption of this hypothesis? It must be admitted by all who had studied distribution in any group of animals that there were many such difficult cases. The lecturer then proceeded to call attention to six cases of abnormal distribution in the classes of mammals, birds and reptiles, namely:—

(1.) *The Little Blue Magpie of Spain.*—The general character of the birds of Spain did not differ materially from that of the rest of Southern Europe, although a few North African species intruded into its limits. One little bird only seemed to have been introduced from afar, and disturbed the general uniformity. The little blue magpie of Spain (*Cyanopica Cooki*) had not only no near relatives in the rest of Europe, but we must go to the farthest part of Siberia and Northern China before we met with its true allies. Here was found the *Cyanopica cyanea*, so closely allied to the Spanish bird as to be barely distinguishable. This was, therefore, an undoubted instance of a discontinuous generic, if not specific, area, and in order to bring it within ordinary rules it was necessary to suppose that the parent-form had been formerly existent throughout Europe and Central Asia, but had for some reason become extinct in those countries.

(2.) *Oxyrhamphus and Neomorphus.*—These two South American genera of birds offered somewhat parallel cases of broken distribution. Of the peculiar Passerine form *Oxyrhamphus*, only two very closely allied species were known, one (*O. flammiceps*) in Southeastern Brazil, and the other (*O. frater*) in Central

America, the genus being quite unrepresented in the intermediate countries. In the Cuculine genus *Neomorphus*, the Central American form (*N. Salvini*) was again very nearly similar to the Brazilian (*N. Geoffroyi*), whereas in the intermediate countries three other quite distinct species were known to occur.

(3.) *Pitta Angolensis.*—Not less than from thirty to forty species of the brilliantly colored birds of the genus *Pitta* were known to science, distributed from India, on the north, through the great Asiatic islands into Northern Australia. But one single *Pitta*, in every way typical in structure, and closely allied to an Indian species, occurred in a limited district of Western Africa, the genus being quite unknown in intermediate localities. This was a clear instance of a discontinuous generic area.

(4.) *The Solenodon of the Antilles.*—The insectivorous mammals, according to the best authorities, constituted ten different families, which were mostly restricted to the Palearctic, Indian and Ethiopian regions, and were entirely unrepresented in Australia and South America. Two families only extended into the northern portion of the New World, the moles (*Talpidæ*) and the shrews (*Sorecidæ*). But there was one very exceptional case. The genus *Solenodon*, two species of which were known from two islands in the West Indies, belonged not to the shrews or moles, but to the family *Centetidæ*, otherwise entirely confined to Madagascar. If, therefore, the descent of *Solenodon* and *Centetes* from a common ancestor were assumed, the following assumptions must also be made. First, that the West India Islands had been united by land to Africa; and secondly, that the *Centetidæ* had formerly extended all through Africa, where there were now no traces of them.

(5.) *The Distribution of Lemurs.*—Recalling *Solenodon* to our minds, we might well have expected that the Lemurs, one of the most prevalent and characteristic mammal groups of Madagascar, would have had allies in America, but such was not the case. The only members of this group not found in Madagascar were met with in Africa and parts of the Indian region. It was therefore manifest that, assuming the origin of the Lemurs from a common source, a continent must have formerly existed in the Indian Ocean, and formed the ancient home of the Lemurine family, of which the fragments were now so widely sundered. It would, however, be difficult to reconcile this hypothesis with that of the former land-connection of Madagascar with the Antilles through Africa, previously adverted to.

(6.) *The Giant Land Tortoises.*—The giant land tortoises, which had lately formed the subject of the elaborate studies of Dr. Günther, presented a still more extraordinary instance of anomalous distribution. These animals now only existed in the Galapagos Islands and on the coral reef of Aldabra, northwest of Madagascar, but a third group, which formerly inhabited the Mascarene Islands, had only recently become extinct. In order to derive these three groups of allied species from the same stock, it

would be necessary to assume first that giant land tortoises were formerly distributed all over South America and Africa, where no traces of them now existed; secondly, to suppose that the Galapagos were formerly united to America; and thirdly, that the Aldabra reef had once formed part of land that was joined to the African coast. But even then all the difficulties would not have been surmounted, for it appeared that the Mascarene form of these tortoises was more nearly allied to that of the Galapagos than to that of Aldabra. It would further have to be assumed therefore, in order to bring these facts into harmony with the usual theory, that the Mascarene Islands had remained united to the African coast after the Aldabra reef had been separated from it.

These six cases were only selected instances of the many difficulties met with in endeavoring to account for all the known facts of distribution by the hypothesis of the derivative origin of species. It would be easy for those who had studied distribution in any group of animals to add to them almost indefinitely. Two other more general phenomena of distribution, which it appeared to be difficult to reconcile with the derivative hypothesis, were also briefly adverted to, these were the existence of "tropicopolitan" forms, that is, of forms common to the tropics of both hemispheres, and the presence of several closely allied species in the same area. In the first case, it was difficult to understand where the continent could have formerly existed which afforded a home to the ancestors of the similar species now so widely separated. In the second place, it never appeared to have been explained satisfactorily how more than one form could have succeeded to a pre-existing one in the same area, and the hypothesis that allied forms had always originated in separate areas, and had come together into the same area by immigration, appeared, in some cases to be almost untenable.

These and other minor difficulties had led the author rather to question whether identity of structure must be taken, *without exception*, as an indication of immediate descent from a common parentage. At any rate, the subject seemed to be one still open for discussion, and not, as some recent writers had appeared to assume, a matter which must be regarded as fully and incontrovertibly set at rest.—*Royal Institution*, Feb. 1878.

5. *Corals of the Atlantic.*—G. Lindström has described and figured several new corals from the Atlantic bed, in a paper in the Transactions of the Swedish Academy, vol. xiv, 1877.

IV. Miscellaneous Scientific Intelligence.

1. *Transactions of the Connecticut Academy of Arts and Sciences*, Vol. III, Part 2.—This part closes the volume. It contains a paper by S. F. Clark, on the Hydroids of the Pacific Coast south of Vancouver Island; by F. M. Turnbull, on the anatomy and habits of *Nereis virens;* by J. K. Thacher, on Median and Paired Fins, a contribution to the history of verte-

brate limbs; by S. I. Smith, on the early stages of *Hippa talpoida;* by J. Willard Gibbs, on the equilibrium of heterogeneous substances, this last paper occupying 220 pages of the number.

Mr. Thacher closes his excellent paper—the second on vertebrate limbs—with the following addendum.

Since the views expressed in the foregoing pages were complete in my own mind six or eight months ago, I had looked for confirmation of them in the brilliant investigations of Balfour on the development of Elasmobranchs. The preliminary account, however, in the Journal of Microscopical Science, contained nothing bearing on the point, and the papers in the Journal of Anatomy and Physiology I have been able to obtain only irregularly. Immediately after the last proof of the preceding pages had been received, the number of that Journal for October, 1876, came into my hands. Here Balfour devotes three or four pages to the limbs. He says: "If the account just given of the development of the limb is an accurate record of what really takes place, it is not possible to deny that some light is thrown by it upon the first origin of the vertebrate limbs. The fact can only bear one interpretation, viz: *that the limbs are the remnants of continuous lateral fins.*"

"The development of the limbs is almost identically similar to that of the dorsal fins." He goes on to state that while none of his researches throw any light on the nature of the skeletal parts of the limb, they certainly lend no support to Gegenbaur's view of their derivation from the branchial skeleton. Thus these results have not only been reached independently, but from two different classes of facts. To the belief in the original continuity of the lateral fins and the homodynamism of median and paired fins I was led by observations on adult forms, and particularly on the skeleton. Balfour comes to the same results from embryological investigations, in that group from which on general grounds an answer was most to be expected; nor do these investigations regard the skeleton.

I have also just received the last number of the Morph. Jahrb. It contains a paper by Wiedersheim* confirming Gegenbaur's view respecting the double nature of the centrale. This had previously been shown only in the tarsus of *Cryptobranchus Japonicus* (and in the Enaliosaurs). Wiedersheim shows its double character in three Siberian species of Urodela, in both carpus and tarsus. This is a very important confirmation of the chiropterygium, and relieves us of suspicions with regard to its correctness when we push our inquiries into earlier history and more simple forms.

In the same number of the Jahrbuch is a paper by Gegenbaur† on the archipterygium theory. He modifies his explanation of the Stapediferal limb to accord with Huxley's view of the homol-

* Morph. Jahrb., Bd. ii. Hft. 3. R. Wiedersheim, Die ältesten Formen des Carpus und Tarsus der heutigen Amphibien.

† C. Gegenbaur, Zur Morphologie der Gliedmaassen der Wirbelthiere.

ogy of edges and faces of limb and fin. He says that while he does not think the correctness of this view fully demonstrated, still he thinks there is a decided balance of probability in its favor. Therefore the ulnar side of the arm now appears as the *Stammreihe*. In other particulars Gegenbaur reaffirms his previous views. He proceeds to devote considerable space to the discussion of the origin of the archipterygium, and again proposes to assimilate the limb and limb-girdles to the gill-arches with their rays. He supports this suggestion with considerable argumentation. To this position the archipterygium theory leads him.

2. *National Microscopical Congress.*—By invitation of the Indianapolis Lyceum of Natural History and the coöperation of other societies a call has been sent out for the meeting of Microscopists at Indianapolis in August, to be continued for not more than a week, and to commence on the 14th of that month. The Governor and other State officers, and the Mayor and citizens of the place, have united in offers of hospitality to the convention; and fare at reduced rates can be obtained by members at the best hotels ($2.00 at the Bates House, Grand Hotel and Occidental Hotel, $1.75 at the Remy Hotel). Those who may attend the convention are desired to bring scientific communications, instruments, objects for the microscope, and whatever pertains thereto that "will instruct their fellow-workers with the microscope." Letters should be addressed to W. WEBSTER BUTTERFIELD, M.D., Secretary of the Committee of Arrangements. The daily sessions will be held in Hall Nos. 52, 54, 56 and 58 of the Court House. The time for the Congress is one week before the meeting of the American Association at St. Louis.

3. *Geographical Surveys west of the 100th Meridian*, in charge of First Lieut. G. M. WHEELER, under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. A. Vol. II. *Astronomy and Barometric Hypsometry.* 572 pp. 4to. Washington, 1877.—This volume from the Wheeler Expedition under the War Department, consists in Part I of special Astronomical Reports, and in Part II of a Report on Barometric Hypsometry. The first comprises numerous tables of observations made for the purpose of time, latitude and longitude determinations, at various places in Utah, Wyoming, Montana, Colorado, New Mexico, Nevada and Nebraska, together with the geographical positions arrived at and other particulars connected therewith, and is illustrated by map sketches of the principal places and stations, and a plan of the Observatory at Ogden, Utah. The authors connected with these reports are Dr. F. Kampff, J. H. Clark, W. W. Maryatt, Professor T. H. Safford, W. A. Rogers.

The results of barometric hypsometry are from observations made in the years 1871 to 1875 included, and reported by First Lieut. W. L. Marshall, Corps of Engineers, U. S. A. The instruments are described, the methods of observing, and tables of altitudes are given. The report also contains tables of hourly observations of barometric, thermometric and hygrometric and other phenomena

at different places where the parties were encamped, and diagrams on sixteen plates giving the horary and diurnal barometric curves, temperature, mean differences of wet and dry thermometers, diurnal force of vapor, and relative humidity.

4. *Die Vereinigten Staaten von Nord Amerika*, von Dr. FRIEDR. RATZEL. Erster Band. *Physikalische Geographie und Naturcharakter*, mit 12 Holzschn. u. 5 Kart. in Farbendruck. 668 pp. large 8vo. Munich, 1878.—This very large and beautifully printed work is the first of two volumes on the United States, and treats of the physical geography and natural features of the country. The work has been prepared by one who has well mastered his subject, through the writings of the various American contributions to it—those of the earlier and later exploring expeditions, the principal State Geological Reports, the works of Lyell, Fremont, J. D. Whitney, Guyot, Humphreys and Abbott, Walker's Statistical Atlas, Schott's table and results of Precipitation, and others; and he has presented the facts in a judicious and systematic manner. The maps are handsomely colored and illustrate the geology (from Blake and Hitchcock's map), surface relief, forest-distribution, and other characteristics.

The volume opens with a general sketch of the Continent, and of the outlines of the country. Then follow—a brief review of the geology of the United States; an account of the surface reliefs, occupying 115 pages; of the rivers, lakes, hot springs, etc.; the climate; and the distribution of plants and animals. The second part of the volume occupying the following 200 pages, contains special descriptions of different natural sections of the country—for example, forest regions, prairies, New England, the Atlantic coast, the Florida Keys, Cypress swamps, the Western plains, the Bad Lands, "California natur;" the Sierra Nevada, the Great Lakes, and other topics. The second volume will be occupied with the "culturgeographie" of the United States; and will give the facts with fulness like the first, and with reference to the practical rather than the theoretical.

5. *Report upon Forestry;* by FRANKLIN B. HOUGH. 650 pp. 8vo. Washington, 1878.—This report by Mr. Hough was prepared under the direction of the Commissioner of Agriculture, in pursuance of an act of Congress, of August, 1876. It is a practical, comprehensive work, embracing a wide range of topics bearing on forest waste; forest growth; forest lands and reservations; forest distribution; forest culture as affected by legislation, climate, treatment; methods of tree planting and effects of the various kinds of soils and exposures; the cultivation of special kinds of trees; uses of woods, charcoal, the resins and other products of trees; insect ravages and the consequences of other enemies, with the modes of prevention; a general detailed discussion of climate in this and other countries, in its bearing on the subject, with the experiences and experiments of the nations of Europe and elsewhere; effects of forests on climate; forest legislation over the world; forest resources and culture in different

United States; lumber statistics; and various other topics, on all of which the author has brought forward a great amount of valuable facts, and in a manner to enlighten and benefit every part of the country.

6. *Bulletin of the Bussey Institution*, vol. ii, Part iii, 1878.—This number of the Bussey bulletin contains the following papers: on the hybridization of Lilies by F. PARKMAN; on the composition of *Equisetum arvense* by F. H. STORER; composition of shells of crabs and lobsters, and those of oysters, clams, mussels, etc., id.; prominence of carbonate of lime as a constituent of solutions obtained by percolating dry cultivable soils with water, id.; Supplementary note to an article on the composition of pumpkins, id.; a list of Fungi found in the vicinity of Boston, with remarks, by W. G. FARLOW.

7. *The Speaking Telephone, Talking Phonograph, and other Novelties;* by GEORGE B. PRESCOTT. 432 pp. 8vo, with numerous illustrations. New York. 1878. (D. Appleton & Co.).—This volume contains a complete account of the Telephone and Phonograph, in their various forms, with a large number of excellent figures illustrating their construction and mode of use, and also diagrams of the vibrations or "logographic records" of the phonograph. It also treats of Quadruplex telegraphy at much length, giving many detailed figures in the course of the chapter.

8. *The Naturalist's Directory for* 1878. Edited by S. E. Cassino. 184 pp. 12mo. Salem, Mass., 1878.—This well arranged catalogue of the names and addresses of all "naturalists of America north of Mexico," and of all Scientific Societies, is a very useful and convenient work to those who are interested in any way in science, even if not doing more than collecting a cabinet. The new edition, just published, appears to be very complete. The editor states in his preface that he will be thankful for corrections and additions.

9. *Fownes's Elementary Chemistry*, revised and corrected by Henry Watts, B.A., F.R.S., a new American from the 12th English edition, edited by ROBERT BRIDGES, M.D., Professor of Chemistry, Philadelphia College of Pharmacy. 1026 pp. 8vo. Philadelphia, 1878. (Henry C. Lea).—A new and improved edition of this very convenient manual.

10. *Journal of the Cincinnati Society of Natural History.* Vol. I, No. i, April, 1878. 52 pp. 8vo, with two plates.—Contains contributions to paleontology by S. A. Miller and C. B. Dyer, describing various Silurian fossils, figures of which are given on the plates; also a paper on a new species of Pupa by C. R. Judge; and another on the tongue of some Hymenoptera by V. T. Chambers.

11. *Glaciers of the Western Himalayas.*—The glaciers of the Western Himalayas, according to measurements recently given in the *Tour de Monde*, far surpass in extent any hitherto examined outside of the polar regions. In the Mustagh range, two glaciers immediately adjoining one another possess a united length of sixty-five miles. Another glacier in the neighborhood is twenty-

one miles in length, and from one to two miles in width. Its upper portion is at a height of 24,000 feet above the level of the sea, and its lower portion terminating in masses of ice 250 feet in height, and three miles in breadth, is 16,000 feet above the sea.—*Nature*, July 4.

12. *Instructions for observing the Total Solar Eclipse of July 29, 1878.* Prepared by Professor WM. HARKNESS and issued by the United States Naval Observatory. 30 pp. 4to. Washington, 1878.

Elements of Dynamic: an Introduction to the study of motion and rest in solid and fluid Bodies; by W. K. CLIFFORD, F.R.S.—Part I, Kinematic. 222 pp. 12mo. London. 1878. (Macmillan & Co.).

OBITUARY.

WILLIAM M. GABB died, of consumption, on the 30th of May last, at Philadelphia, where he was born on the 20th of January, 1839. In 1862, Mr. Gabb entered upon the duties of paleontologist of the Geological Survey of California, under Professor J. D. Whitney. The larger part of the first volume on the paleontology and the whole of the second, are occupied with his reports on the Cretaceous and Tertiary fossils of the State; the two illustrated by sixty plates of fossils. In 1868 he undertook a survey in Santo Domingo for the Santo Domingo Land and Mining Company; and in 1873 published an extended memoir on the Topography and Geology of that island in the Transactions of the American Philosophical Society (vol. xv). In 1873 Mr. Gabb went to Costa Rica, under an appointment from the government of the State, and engaged in a topographical and geological survey of the territory, in which he made also extensive ethnological and natural history collections for the Smithsonian Institution. A memoir on the topography of the country, with a map, was published in *Petermann's Mittheilungen;* and another, on ethnology, in the Transactions of the American Philosophical Society. But an extensive report on Costa Rica geology and paleontology remains to be published. Various papers of his have appeared also in the Proceedings of the Philadelphia and Philosophical Society; and several in this Journal, the last in the number for March of the current year. Mr. Gabb was a man of vast energy, and an earnest and careful investigator. His various contributions to science are a great honor to the country—and eminently so to the State of California, for which a large share of his work was done.

BARON VON BIBRA died on June 5th at Nuremberg, in his seventy-second year. He was the author of various chemical, zoological, physiological, archæological and literary works and memoirs. He explored Brazil, Chili and some other parts of South America, and published accounts of his observations and his discoveries in natural history. He is the author also of many popular works of fiction, the scenes of several of which were laid in South America.

ANDREAS VON ETTINGSHAUSEN, Professor of Physics at Vienna, died on the 25th of May, having been born in Heidelberg, Nov. 25, 1796.

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ART. XV.—*On the Origin of Comets*; by H. A. NEWTON.

1. KANT in the exposition of his theory of the development of the solar system treats the comets as formed from the matter of the condensing solar nebula. To him they were planets, in fact, but somehow thrown out of their normal circular orbits. Although he gave for this origin of the comets no reasons which astronomers can respect, yet it is proper to call the hypothesis by his name. On the other hand, Laplace in his exposition of the nebular hypothesis considered that the comets were made from the matter that is scattered through the stellar spaces, and that in their origin they have no relations with the solar nebula. Have we in our accumulation of facts since the times of Kant and Laplace learned any thing which helps us to decide between these two hypotheses? I propose to consider what peculiarities each of them requires in the shape and distribution of the cometic orbits, and then compare with the theories the observed facts.

2. For convenience I shall assume that the solar system has been brought into its present condition by some process of development. Hence the comets have not through all past time moved, even approximately, in their present orbits. After the comets became separate parcels of matter two kinds of forces could alter the forms of their orbits, resistance of a medium (if such exists), and the attraction of gravitation of the sun and planets.

3. Nearly all the comets that we have seen, and have computed the orbits of, come nearer to the sun than the planet Mars. The exceptions are only about five per cent of the

whole number. We may therefore assume that comets to become visible to us ought, in general, to come nearer to the sun than that planet. All others may be regarded as permanently invisible. There is, however, no reason to doubt that many such unseen comets exist. Even those which we see become invisible at a moderate distance from the earth and sun.

4. The orbits of most comets are so near to a parabolic form that it is only when they are very well observed that we can detect any deviation therefrom. They pass to a great distance from the sun, and it is reasonable to suppose that their origin, even on Kant's hypothesis, was remote from the sun. We must interpret that hypothesis as meaning that some of the parcels of matter that would normally have gone to make up *distant* planets became scattered into comet masses.

5. Consider such a parcel, or comet mass, A, at a point such that the line AS from A to the sun S is large; for example, 1,000 times the distance from the earth to the sun. Now if the velocity of A exceeds the small velocity acquired by a body falling by attraction from an infinite distance down to A, that is, exceeds the velocity in a parabolic orbit, then by the law of gravitation the orbit of A around S must be an hyperbola. The more the velocity of A is in excess of the parabolic velocity the more manifestly will the hyperbola differ from a parabola. But, since the known comet orbits, if any of them are hyperbolas, differ little from parabolas, we are permitted to assume for them a velocity at the distance AS not largely in excess of the parabolic velocity. All other orbits we have nothing to do with. Laplace proves satisfactorily that we ought, by the theory of probabilities, rarely to see such comets.

6. Let now the velocity of A be resolved into two parts by the parallelogram of motions, one component along AS, and one at right angles to AS. The part at right angles to AS will be very small compared with the parabolic velocity for the point A. Otherwise the comet, whatever is the curve it is describing, would go around the sun at a great distance, and would belong to the class of comets that are always invisible to us and with which we have, therefore, nothing to do.

7. Consider a large number of comets passing through the point A, or rather shot from the point A. Through S draw a plane perpendicular to AS, and on that plane draw a circle whose radius is twice the radius of Mars' orbit. That plane and circle we may regard as a target at which the several cometic masses may be regarded as launched. Only those whose velocities perpendicular to AS are small will strike within the circle, and so coming nearer to the sun than Mars will form part of the group of comets which we know anything about.

8. Besides these we must suppose that there is a large number of cometic masses which will strike the plane outside of the circle. If there is any law of distribution of the initial directions and velocities of the masses at A, that law will be exhibited in the distribution of the points of impact with the plane. Thus if like the principal members of the solar system the masses leave A with a velocity belonging to a circular orbit, nearly at right angles to AS, and nearly in the plane of the solar system, then the points of impact in the target plane will be near each other at a distance from S equal to AS; for the masses will describe circles, approximately. Again, if the masses pass through A on their way from the stellar spaces and so have motions that bear no relations to the motions of the solar system, then the distribution of the points of impact on the target plane ought if numerous enough to be uniform about the point S.

9. In any case the area of the points of impact ought to be large compared to the area of the circle above described. The initial velocities perpendicular to AS must, if small, be differences, or small residuals of larger opposing velocities. Thus, if the masses were parts of the original solar nebula, their normal motion by all the analogies of the system should be in circles. For some reason these masses never had much projectile velocity perpendicular to AS, or else they have lost most of it. The forces producing this might as easily have caused the small residual velocity to take any direction whatever normal to AS. An important deduction may be thus stated. If any where in the large area of the target plane over which the points of impact are distributed, a small circle be described, the distribution of the points within the circle must be nearly uniform. If AS is large then the circle above described about S as a center will be relatively a small circle. Divide this circle by eighteen diameters into thirty-six equal parts. Each of these parts should contain equal numbers of the points of impact.

10. Take now one of these diameters as an initial line, and the plane passing through it and AS as the plane of reference. Consider the orbits corresponding to the points of impact of the two ten-degree sectors that lie each side of the positive half of the initial diameter. The inclination of these orbits to the reference plane will be between 0° and 10°.

The orbits corresponding to the points of impact in the two sectors next beyond (one on each side) will have inclinations between 10° and 20°; and so on, up to 180°. Hence, the numbers of orbits whose inclinations to any arbitrarily selected plane passing through AS are within each decade of degrees from 0° to 180° should be equal: in other words, where AS is large, *the distribution of the inclinations of the orbits through the two right angles should be uniform.*

11. But if AS is not large the above stated conclusion (10) would not hold true. Thus if the comets came from the region between Mars and Jupiter, being, for example, asteroids somehow thrown out of the usual region of the asteroid orbits, the total area of the impacts in the target plane would not be large relative to a circle whose radius is equal to the diameter of the orbit of Mars. The distribution of the inclinations of the orbits would in that case naturally exhibit some evidence of the law of distribution of the original motions.

12. Suppose, however, that the cometic masses are made from the more distant matter of the solar nebula, matter that should perhaps have gone to form a planet outside of the orbits of known planets. The masses must be supposed to come from points in or near the plane of the solar system, which for present purposes may be regarded as the ecliptic. Referring their inclinations to that plane, those inclinations, for reasons like those given above (10), should have been originally uniformly distributed through the two right angles from 0° to 180°. The aphelia of the orbits should all have been near the ecliptic.

13. But suppose, on the other hand, that the cometic masses are made from the matter in the stellar spaces. The points from which they approach the sun are no longer, as under the other supposition, points in or near the ecliptic. These points are scattered over the heavens uniformly. For, only those masses whose motions through space are very nearly equal to the sun's motion can come within sight of the earth. The small residuals that represent the relative motions of comet to sun must, therefore, by reason of their smallness be nearly independent of original absolute motions, and hence the points of origin should be equally distributed over the heavens.*

14. If now we consider a very large number of orbits and draw lines through the sun at right angles to the plane of each orbit, the points where these lines meet the celestial sphere will be the poles of the planes of the orbits, and their distribution over the heavens must be uniform. For the directions from which comets enter the solar system are uniformly distributed (13), and the poles for any direction of the line AS are uniformly distributed (10) about that line. Hence there is no reason why there should be more poles in one part of the heavens than in another.

15. If we refer these orbits (14) to the ecliptic, the inclination of any orbit to the ecliptic will be equal to the distance of the two poles from each other, the pole of the orbit from the pole of the ecliptic. If we divide the surface of the celestial

* Prof. Schiaparelli by introducing (improperly, as I am sure he will concede) the motion of the sun in space was led to decide against a foreign origin for comets. See Analyst, I, p. 80.

sphere into 18 zones by parallels of latitude at even decades of degrees from +80° to −80°, then the orbits whose positive poles lie in the northernmost segment will have inclinations less than 10°.* The orbits whose positive poles lie in the next zone will have inclinations between 10° and 20°, and so on up to 180°. Hence the numbers of the orbits whose inclinations to the ecliptic are included in the successive decades of degrees will be as the areas of the zones. But these zones are as the sines of 5°, 15°, 25°, etc. Therefore we conclude that if the comets come from the stellar spaces their original orbits should have been so distributed that the numbers of orbits whose inclinations to the ecliptic fall in the successive degrees from 0° to 180°, should have been proportional to the sines of inclinations. The distribution of the aphelia would have been uniform over the heavens. Hence their relative frequency at different latitudes would have been as the cosines of the latitudes.

17. We may represent the distribution of the inclinations by a diagram. Let the axis of abscissas (fig. 1) extend from 0° to 180°, and upon this describe the first half cycle of the curve of sines, $y=a \sin x$. Draw also the straight line, AB, parallel to the axis of abscissas, $y=\frac{2a}{\pi}$. The ordinates of the two lines represent the original distributions of the inclinations from 0° to 180° of a given number of orbits according to the two theories. The aphelia, according to one theory, are distributed in latitude as the cosines of the latitudes, in the other they are all in the ecliptic.

18. If the comets came from the stellar spaces their original orbits were hyperbolas. If they originated from our system they were ellipses. In either case if their origin was very distant the orbits would have differed so little from parabolas that the deviations in portions visible to the earth would, in general, be covered up by the ordinary errors of our observations. If the orbits had remained unchanged by perturbations the question of origin would be simply decided by determining whether the orbits are now elliptic or hyperbolic. But the hyperbolic orbits might be changed by a resisting medium (if there is one) into ellipses, and perturbations by a large planet may change ellipses into hyperbolas, or hyperbolas into ellipses. If there is any known orbit of a comet that is beyond question hyperbolic, and its path was such that in approaching the sun at its present appearance it did not so pass near to a large planet as to have its velocity thereby increased, then that comet at least must be regarded as coming to us from the stellar spaces. Hyperbolic orbits have been assigned to certain comets, but is the hyperbolic character of any of them not open to reasonable

* By positive pole is meant that pole from which the comet's motion appears to be opposed to the motion of the hands of a watch.

challenge? On the other hand, if the comets, or any of them, originate within the solar system, and not at a great distance from the sun, their orbits would be short ellipses, and their motions might be expected to be somewhat like those of the planets. The fact that most of the periodic comets move in orbits of small inclinations to the ecliptic, it must be admitted, is, till otherwise explained, a very strong argument that they, at least, always formed part of the solar nebula.

19. The original distributions of the aphelia and of the inclinations were stated above. But the comet becomes subject to perturbations, and, if it was, or, if it becomes a permanent member of the system then the perturbations may accumulate so as to destroy or conceal the original law. It is not easy to give useful expressions for the secular perturbations for an orbit of large excentricity and inclination. But the general tendency of the forces would seem to resemble somewhat that of their action upon the moon and the planets. Here the line of apsides has a progressive secular motion, while the inclination remains quite constant. The effect of a resisting medium, if one exists, would be to shorten the periodic time and to leave the plane of the orbit unchanged. The effect upon the line of apsides would not be large.

20. The present distribution of the aphelia is not critical between the two hypotheses. For progression of the line of apsides would in time distribute the aphelia of the orbits if either hypothesis be true pretty uniformly over the heavens. The actual distribution at the present time of the aphelia in latitude for known orbits is very nearly as the cosine of the latitude. The principal exception is a slight excess of numbers in the small latitudes. One conclusion may be safely inferred from this thorough distribution over the heavens; that is, that if Kant's hypothesis be true, the period of past time since the comets were aggregated and made to describe these long orbits has been a very great one, and the process of disintegration of comets is a very slow one. These facts, so far as they have force, favor the foreign origin of comets.

21. The general effect of small perturbations of a planet upon the orbits of comets would be to increase the inclination of some and diminish that of others.

If a comet passes Jupiter on one side the inclination may be increased. This, however, is balanced by the diminution of the inclination of another comet moving in a parallel path on the opposite side of the planet, or, if you please, by one coming on the same side of Jupiter but from the opposite direction. The total effect would at first sight seem to be neither to increase nor diminish the average inclinations.

22. The present actual distribution of the inclinations is

then of such import as to be carefully considered. From the list of known cometic orbits I have rejected those for which the data on which they were computed seemed to me to be too slender to furnish an orbit worth retaining in the present investigation. There remained the following 247 orbits, arranged in the table according to their inclinations, which are stated to the nearest degree.

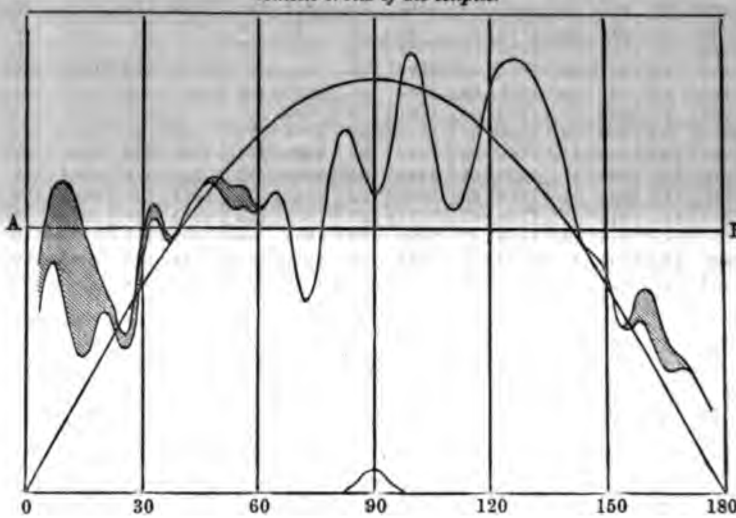
Table showing the inclinations of the known cometic orbits.

Year.	Inc.	Year.	Inc.	Year.	Inc.	Year.	Inc.	Year.	Inc.	Year.	Inc.	Year.	Inc.
1743	2°	1556	32°	1845	56°	1672	83°	1871	102°	1739	124°	1857	142°
1770	2	1779	32	1790	57	1774	83	1877	102	1857	124	1843	144
1678	3	1811	32	1802	57	1863	83	1799	103	1824	125	1806	145
1844	3	1874	32	1804	57	1846	85	1665	104	1780	126	1825	146
568	4	1532	33	1840	58	1849	85	1823	104	1822	126	1847	147
1702	4	1661	33	1874	58	1861	85	1577	105	1827	126	1870	147
1585	6	1857	33	1680	60	1863	85	1821	106	1764	127	1718	149
1746	6	1874	34	1773	61	1863	85	1842	106	1822	127	1770	149
1834	6	1618	37	1810	62	1762	86	1558	107	1596	128	1790	149
1833	7	1851	38	1853	62	1593	88	1811	107	1784	129	1590	150
1869	7	1737	39	1807	63	1857	88	1847	108	1797	129	1846	151
1766	8	1826	40	1863	64	1707	89	1854	109	1799	129	1781	153
1819	9	1850	40	1580	65	1825	89	1864	110	1855	129	1877	153
Tem.	10	1769	41	1788	65	1818	90	1699	111	1723	130	1855	157
Faye	11	1852	41	1684	66	1826	91	1869	112	1792	131	1664	159
Win.	11	1854	41	1874	66	1865	92	1742	113	1844	131	1801	159
1771	11	1874	42	1748	67	1871	92	1863	113	1845	131	1813	159
Enc.	13	1816	43	1849	67	1785	93	1854	114	1852	131	1858	159
Biela	13	1798	44	1849	67	1748	95	1862	114	1787	132	1853	160
1757	13	1815	45	1758	68	1683	96	1796	115	1868	132	Hal.	162
Tem.	13	1844	46	1850	68	1848	96	1790	116	1743	134	1866	163
1854	14	1744	47	1785	70	1859	96	1877	116	1808	134	1864	163
D'Ar.	16	1845	47	1763	73	1873	96	1818	117	1506	135	837	164
1737	18	1846	47	1812	74	1847	97	1858	117	1830	135	1698	168
1867	18	1783	48	1851	74	1854	97	1582	119	1864	135	1788	168
1847	19	1860	48	1729	77	1867	97	1853	119	1827	136	1855	170
1818	20	1847	49	1877	77	1871	98	565	120	1832	137	1835	171
1618	21	1864	49	1863	78	1813	99	1793	120	1701	138	1862	172
1830	21	1846	50	1652	79	1870	99	1840	121	1798	138	1759	175
1695	22	1786	51	1759	79	1874	99	1857	121	1861	138	1472	178
1858	23	1793	52	1860	79	1847	100	1877	121	1862	138	1864	178
1826	26	1840	53	1860	79	1858	100	1846	122	1337	139		
Bror.	29	1843	53	1840	80	1433	101	1853	122	1766	139		
1873	30	Tuttle	54	1861	80	1677	101	1870	122	1792	140		
1846	30	1706	55	1819	81	1747	101	1873	122	1808	141		
1686	31	1824	55	1781	82	1827	102	1825	123	1822	142		

23. The usual method of arranging these inclinations for use and exhibition in a diagram is to divide the 180° into suitable equal divisions, and count the number of comets in each division. Another method seemed, however, better suited to the present purpose, and as it is believed to be well adapted to many similar discussions, I describe it as briefly as possible. Each orbit is represented by the area of a probability curve of

such parameter as was judged suitable. In the present discussion in the equation of the curve $y=ce^{-h^2x^2}$, I assumed $h=0{\cdot}2$. This makes the average removal of the area from the central ordinate less than 3°. The area for one orbit at an inclination of 90° is represented in fig. I. at the bottom of the figure. A similar area is assigned to each one of the 247 orbits and is supposed to be placed centrally on the ordinate corresponding to its inclination. The total ordinate for any abscissa is the sum of the corresponding ordinates of these several small areas. The result is exhibited in the figure by the upper irregular curved line. The line cannot be carried within two or three degrees of the extreme ordinates without some assumption of numbers beyond 0° and 180° in the original table, and such assumption is, of course, not allowable.

Fig. 1: *showing the theoretical and the social distributions of the inclinations of the cometic orbits of the ecliptic.*



24. The periodic comets form so peculiar a group that it was well to separate them from the rest. There are thirteen such comets, if we add to the ten certainly seen at different returns the comet of the November meteors (1866 I, seen undoubtedly in 1366), Lexell's comet, (1770 II), and Di Vico's, (1841 I). The shaded area is the part contributed by these thirteen comets, and the lower curved line represents the distribution for the remaining comets.

We have then in the line AB, fig. 1, the expression of the law of original distribution of the inclinations required by the hypothesis of Kant; in the smooth curve, or curve of sines, that

of the law of distribution required by the hypothesis of Laplace; and in the irregular curves, the actual present distribution of 247, and 234, known orbits. Does the present fact most favor the one hypothesis, or the other? The smaller irregularities of the curve are, of course, due to chance. But there are certain large differences between the fact and each hypothesis which show either systematic action of perturbations, or else that neither hypothesis as stated is exclusively true. The form of the question may be this: after allowing for any perturbations and principles of selection that have acted on the orbits of known comets, would the curve of fact in the figure agree most nearly with the one, or with the other hypothesis?

25. There may be some principle of selection, some cause why it is easier, or harder, to discover comets of small inclinations than those nearly perpendicular; or those of direct than those of retrograde motions. But I have not been able to establish the action of any such principle. The perturbations only will therefore be considered.

If the comets come from without, and are now permanent members of the solar system, as many of them certainly are, their velocities for given distances from the sun have been diminished by perturbations. If this diminution is due to a resisting medium there is no resulting effect upon the inclinations of the orbits: but if by comets passing near to planets the inclinations are in general changed. In an individual case the effect may be to increase, or it may be to diminish the inclination. Which effect is most frequent? We can only consider the *average* result, treating the orbits statistically rather than individually.

26. If the planets and sun were fixed centers of force they could not change by their attraction a comet's orbit from an open into a closed curve. It is only to the *motion* of a planet that the change is owing. Let a comet in its orbit come near to Jupiter, for instance. If it passes in front of Jupiter, the comet's potential relative to the mass of Jupiter and the sun is increased without any corresponding increase by Jupiter's attraction of its velocity. If it passes behind Jupiter, then its potential is diminished by Jupiter's motion without any corresponding decrease of velocity.

About Jupiter let there be described a series of level surfaces at equal differences of potential. Then Jupiter's motion in his orbit will carry some of these spherical surfaces past the comet. The difference between the number of spheres entered and the number left *by virtue of Jupiter's motion*, expresses the decrease of the square of the comet's velocity. The surfaces are closer to each other near to Jupiter. Hence the decrease depends on the nearness of approach of the comet to Jupiter, and is propor-

tional to the amount of Jupiter's motion normal to the average direction of the relative orbit.

[This is more definitely shown, if desired, and the quantity of the change is found by solving the equations of motion for this case. Let a be the unit of distance, f the sun's attraction at the unit of distance, v the velocity of the comet in its orbit about the sun, r and r_0 the distances of the comet from the sun and Jupiter, and m the mass of Jupiter (sun's mass $= 1$): then if

$$P = v^2 - \frac{2fa^3}{r} - \frac{2mfa^3}{r_0},$$

any change in P will evidently change the periodic time of the comet in its elliptic orbit, or by diminution of P the orbit may change from an hyperbola to an ellipse.

Let now x, y, z, be the coördinates of the comet relative to the sun, x_1, y_1, z_1, of the planet relative to the sun, x_0, y_0, z_0, of the comet relative to the planet; so that $x = x_1 + x_0$, $y = y_1 + y_0$, and $z = z_1 + z_0$. Neglecting the comet's mass we have for the equations of motion,

$$\frac{d^2x}{dt^2} = -fa^3\left(\frac{x}{r^3} + \frac{mx_0}{r_0^3}\right).$$

$$\frac{d^2y}{dt^2} = -fa^3\left(\frac{y}{r^3} + \frac{my_0}{r_0^3}\right).$$

$$\frac{d^2z}{dt^2} = -fa^3\left(\frac{z}{r^3} + \frac{mz_0}{r_0^3}\right).$$

Multiplying by $2dx$, $2dy$, and $2dz$, adding and observing that $dx = dx_1 + dx_0$, $dy = dy_1 + dy_0$, $dz = dz_1 + dz_0$, we have by reduction,

$$\frac{dP}{dt} = -\frac{2mfa^3}{r_0^2}\left(\frac{x_0}{r_0}\frac{dx_1}{dt} + \frac{y_0}{r_0}\frac{dy_1}{dt} + \frac{z_0}{r_0}\frac{dz_1}{dt}\right)$$

$$= -\frac{2mfa^3}{r_0^2}\left(\frac{x_0}{r_0}\frac{dx_1}{ds_1} + \frac{y_0}{r_0}\frac{dy_1}{ds_1} + \frac{z_0}{r_0}\frac{dz_1}{ds_1}\right)\frac{ds_1}{dt},$$

where ds_1 is the element of Jupiter's orbit about the sun. The quantity in the parenthesis is the cosine of the angle at the planet between the comet's radius vector and the direction of Jupiter's motion, which angle we may denote by φ_0. The factor $\frac{ds_1}{dt}$ is the planet's velocity in its orbit, which may be denoted by v_1. Then we have,

$$\frac{dP}{dt} = -\frac{2mfa^3v_1}{r_0^2}\cos\varphi_0.$$

The integral for P for the time that the comet is within the sphere of Jupiter's special action (that is, while the comet may be treated as moving in a hyperbolic orbit about Jupiter, and the sun only as a perturbing body), gives the change in P

due to Jupiter's motion. Let v_0 be the comet's relative velocity on entering the sphere of Jupiter's action, and p_0 the perpendicular from Jupiter on its relative path at that time. From Kepler's law $r_0^2 d\theta = p_0 v_0 dt$, where θ is the angle in the plane of the comet's relative orbit defining the place of the comet. During the time of the comet's transit past Jupiter his motion may be regarded as in a straight line. Project that line on the plane of the comet's relative orbit, let θ be counted from this projection, and call the angle of projection δ. Then $\cos\varphi_0 = \cos\delta\cos\theta$, and we have,

$$p_0 v_0 dP = -2mfa^2 v_1 \cos\delta\cos\theta\, d\theta.$$

Denoting the total change of P by Δ, and the first and last values of θ by θ' and θ'', we have,

$$\begin{aligned} p_0 v_0 \Delta &= 2mfa^2 v_1 \cos\delta\,(\sin\theta' - \sin\theta'') \\ &= 4mfa^2 v_1 \cos\delta\cos\tfrac{1}{2}(\theta' + \theta'')\sin\tfrac{1}{2}(\theta' - \theta''). \end{aligned}$$

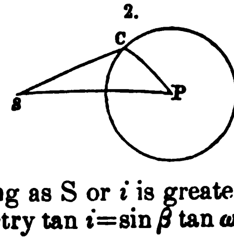
But $\theta'' - \theta'$ is the change of direction of the comet's radius vector, and is approximately that angle of the asymptotes of the hyperbolic orbit which encloses the curve. Denote it by 2α, observing that $\sin\alpha$ will in general be not much different from unity. Again $\frac{1}{2}(\theta' + \theta'')$ is the angle defining the perijove of the comet's orbit, and $\cos\delta\cos\frac{1}{2}(\theta' + \theta'') = \cos\varphi$, where φ is the angle between the direction of Jupiter's motion and the direction from Jupiter of the transverse axis of the comet's orbit. Hence,

$$\Delta = -\frac{4mfa^2 v_1}{p_0 v_0}\cos\varphi\sin\alpha.$$

That is, *the total decrease in the kinetic energy of a comet caused by the perturbing action of a planet during the transit of the comet past the planet is proportional to the continued product of the momentum of the planet* (mv_1), *the cosine of half the angle through which the comet's direction is changed by the planet* ($\sin\alpha$), *the cosine of the angle at the planet between the direction of the planet's motion and the transverse axis of the comet's relative orbit* ($\cos\varphi$), *and the reciprocal of the constant area described in the unit of time by the comet in its relative orbit* ($2 \div p_0 v_0$).]

27. Let CSP (fig. 2) be a triangle on the celestial sphere, C and P being the points from which the comet's and planet's motions are directed when they are near each other, and S the direction of the sun from the planet. If the planet be regarded as describing a circle in the ecliptic, then SP is a quadrant, and CSP is the inclination of the comet's orbit. Denote CSP by i, CP by ω, and CPS by β. CP will be greater or less than a quadrant according as S or i is greater or less than a right angle, and by trigonometry $\tan i = \sin\beta\tan\omega$.

2.



If we suppose a large number of comets to approach the planet so that the value of ω is constant but so that the points from which their motions are directed are equably distributed on the circumference of the small circle whose pole is P, and whose distance from P is ω, then evidently the mean value of tan i is $\frac{1}{\pi}\int_0^\pi \tan\omega \sin\beta d\beta$, that is $\frac{2}{\pi}\tan\omega$.* Therefore the greater the algebraic value of tan ω, the greater that of the mean value of tan i. Hence, also, the greater the value of ω between 0° and 180° the greater the mean value of i, between the same limits. Therefore we may conclude that *when the perturbing action of a planet upon neighboring comets increases the angle between the directions of the motions of the comets and of the planet, that action tends likewise in the mean to increase the inclination of the comets' orbits to the plane of the planet's orbit, and conversely.*

28. Suppose now that a comet passes through the sphere of a planet's action. Denote the planet's velocity by v_1, the comet's relative velocity on entering and on leaving the sphere by v_0, the comet's absolute velocity on entering the sphere by v, and on leaving the sphere by v', the angle which the comet's absolute motion makes with that of the planet on entering the sphere by ω, and on leaving the sphere by ω'. Let also $2V=v+v'$, and $2d=v-v'$. Then by composition of motions,

$$v_0^2=v_1^2+v^2-2v_1v\cos\omega=v_1^2+(V+d)^2-2v_1(V+d)\cos\omega$$
$$=v_1^2+v'^2-2v_1v'\cos\omega'=v_1^2+(V-d)^2-2v_1(V-d)\cos\omega'.$$

Hence reducing, we have

$$\cos\omega-\cos\omega'=\frac{2d}{v_1(V-d)}(V-v_1\cos\omega).$$

If now the action of the planet is to diminish v, both $V-d$ and d are positive, and the sign of $\cos\omega-\cos\omega'$ depends upon that of $V-v_1\cos\omega$. Hence ω is increased by that action when $V-v_1\cos\omega$ is positive.

If $\omega>90°$ this quantity is positive, and at the same time $i>90°$ (27). Since the action of the planet is to increase ω, the resulting value of i exceeds 90°. Therefore, *when the inclination of a comet's orbit is greater than 90°, and the velocity of the comet is reduced by the perturbing action of a planet near to which it comes, the orbit after the perturbation has an inclination greater than 90°; and, if a large number of cases be considered, the mean effect of the perturbations is to increase the inclinations.*

29. Again, for a comet moving in a parabolic orbit we have $v=v_1\sqrt{2}$. Hence, $V=\frac{1}{2}(v+v')>v_1\cos 45°$, and $V-v_1\cos\omega$ is positive when $\omega>45°$. Therefore, *whenever any comet moving in a parabolic orbit passes near to a planet and by the planet's*

* The integration should not extend to the second semicircle, since the comets corresponding thereto belong to the other node.

action has its velocity diminished, the angle between the directions of the motions of the two bodies about the sun is increased in all cases in which that angle is at first greater than 45°.

30. Again, when ω is less than 45°, and the planet before disturbance moves in a parabola so that $v = v_1\sqrt{2}$, then $V - v_1 \cos\omega$ is positive for all values of ω unless $V < v_1$, that is, unless $v + v' < 2v_1$, in other words $2d > 2v_1(\sqrt{2}-1) = 0{\cdot}828v_1$. Therefore, *when a planet overtaken by a comet, the directions of their motions differing less than 45°, has its velocity diminished, that difference of direction will be increased unless the comet comes so near to the planet as to lose by its perturbing action a part of its velocity at least equal to about $\frac{5}{6}$ths of the planet's velocity.*

31. Therefore, it is only in exceptional cases (28, 29, 30) that the shortening by a planet's action of the periodic time of a comet moving in an orbit of long period is not connected with an increase of the angle of divergence of the two motions, and a consequent tendency to increase the inclination of the two orbits. In the exceptional cases the comet overtakes the planet, passes around close to and in front of it, and is thus left behind with an absolute velocity and hence a periodic time much less than that of the planet, and with a direct motion.

32. On the other hand, for given values of v_0 and v_1, and $\omega > 90°$, the smallest value of v' corresponds to $\omega' = 180°$, when $v' = v_0 - v_1$. If the comet approaches in a parabolic orbit $v = v_1\sqrt{2}$, and we have for the smallest value of v',

$$(v^2 + v_1^2 - 2vv_1 \cos\omega)^{\frac{1}{2}} - v_1 = v_1 \left\{ (3 - 2\sqrt{2} \cos\omega)^{\frac{1}{2}} - 1 \right\}.$$

Hence $v' > (\sqrt{3}-1)v_1 = 0{\cdot}73v_1$. Therefore, *when the inclination of a comet's orbit is greater than 90°, and it approaches the planet in a parabolic orbit, it leaves the vicinity of the planet with an absolute velocity greater than $\frac{73}{100}$ths of the velocity of the planet's velocity in its orbit.* We may say that the value of v', when $\omega > 90°$, will be in general much greater than v_1, and therefore may conclude that the comet whose inclination exceeds 90° will rarely by a planet's attraction acting during a single passage be reduced from a parabolic orbit to one whose periodic time is less than that of the planet.

33. Apply now these propositions to the questions stated above (24). If comets are from stellar space they come toward the planets at first a trifle faster than if moving in a parabola. If one of them does not lose velocity, or if passing behind a planet it gains velocity, that comet goes off into space again never to return. But if it passes in front of a large planet, within a moderate distance of it, it loses velocity enough to remain a permanent member of our system.

Most observed comets have on this hypothesis thus lost

velocity. What proportion have not depends upon how fast the process of disintegration of comets goes on. If this process is very slow, the new comers on our list should form a smaller proportion than if the process is rapid. But it has been seen that in the process by which they lose velocity their orbits have their inclinations in general increased. This is particularly true for the inclinations between 45° and 135°, for the corresponding comets are more likely to pass directly across in front of the planets. Hence in fig. 1 we ought to expect on Laplace's hypothesis as a result of perturbations an increase of the ordinates between 90° and 135°, at the expense of the ordinates between 45° and 90°.

Again, the periodic comets form a marked group and should probably be treated separately. Now it is reasonable to suppose that a large part of the area between 0° and 20° lying below the shaded area is due also to comets of short periods. Of the twenty-six comets in the table whose inclinations are less than 20°, nine are noted as periodic and furnish the shaded area near A. Of seven of the remainder, viz: 1743 I, 1678, 1585, 1766 II, 1819 IV, 1867 I and 1847 V, the orbits computed are ellipses, mostly short ones, but the comets have not been certainly detected at any return. Of the other ten about half were not well enough observed to enable us to say whether their periods were short or long. It is probably safe to assume that the area between the curve of sines and the shaded area belongs, up to 20°, to comets of short period. These return so frequently that their number in a list of observed comets is out of all proportion to their number among existing comets. Whatever theory of the origin of this group we may assume they should, because of the comparative ease of their being detected, not count for much in studying the original distribution of the inclinations.

Correct then the curve in fig. 1 by striking off the surplus area below 20°, bringing back some of the area from the second into the first quadrant to counteract the effect of perturbation, and the result corresponds well with the theoretical curve of sines, especially if this curve is slightly reduced in amplitude, as it should be, because of the removal of the periodic comets. We therefore conclude, *that the curve of fact does agree well with that required by the hypothesis of Laplace* if we first make reasonable allowance for known perturbations, and for the comets of short periods.

34. Can the facts of the distribution of inclinations be explained with reasonable suppositions on Kant's hypothesis? I think not. If the comets are from matter at a very great distance from the sun the line AB should represent the theory, and the decided turn of the curve downward towards 180° seems

inexplicable. The same is true for the downward turn of the curve near A when the comets of short period are thrown out, wholly, or in part. The effect of perturbation should be to push the area forward towards B.

But if the comets come from matter somewhat nearer to the sun, the line of theory should start above A and run out below B. The perturbations should then increase some inclinations and decrease others, with a slight tendency, in the mean, to increase them. For the comets whose times are decreased, and, therefore, whose inclinations are increased, would return more frequently and so be more likely to appear in our list, while some of those whose inclinations are diminished would go off altogether. But the perturbations would not easily remove the excess of area from near A in the figure. We therefore conclude *that the curve of fact is not made to agree with the hypothesis of Kant* by simple and reasonable allowances for perturbations.

35. The separate group of comets of short period may, for aught that appears in this discussion, have come either from material of the solar nebula, or from outside. In the former case they would seem to be merely asteroids turned out of the region between Mars and Jupiter, usually occupied by those bodies. If they came from outside there is a reason for their direct motion in the fact that only comets leaving the neighborhood of Jupiter's orbit with a small velocity can move in these short periods, and only comets overtaking Jupiter can have their velocities so much diminished in a single approach to the planet. It is to be considered, however, that a comet leaving the neighborhood of a large planet has peculiar tendency to come again under its influence in subsequent revolutions. A slower velocity of approach changes much the problem at the second passage near the planet.

36. How the comets first became solid is a question of great interest. That they are solid seems evident from the solid nature of the fragments broken off from the comets since they entered the solar system, i. e., the meteorites and meteoroids. The character of these fragments corresponds more with that of the deeper rocks than with those on the surface of the earth. It seems very improbable that iron masses whose like in the earth is found only in the igneous trap rocks, especially in the Greenland traps, should have become consolidated in the cold of space in small parcels. The internal structure of the comet fragments are records of an interesting early history. To decipher the legends belongs rather to the mineralogist and the physicist than to the astronomer. My effort has been to find *where* they were written.

Art. XVI.—*On the Animal of Millepora alcicornis*; by William North Rice.

The attention of zoologists was called to the relations of Millepora by the announcement of Agassiz in 1858 that "Millepora is not an Actinoid Polyp, but a genuine Hydroid, allied to Hydractinia."* Professor Agassiz figured the animals as seen by him, in his Contributions to the Natural History of the United States, vol. iii, p. 61. On the evidence afforded by a single observation of Millepora, he proposed to transfer to the Acalephæ not only that genus, but all the Madreporaria Tabulata of Milne-Edwards. Professor Verrill has shown† that the latter inference cannot be accepted, and that the Madreporaria Tabulata form an artificial and quite heterogeneous assemblage. There has been much difference of opinion as to the soundness of Agassiz's conclusion in regard to Millepora itself, and the extreme shyness of the animals has rendered it impossible to accumulate numerous observations. A paper by General Nelson and P. Martin Duncan,‡ contains figures of the animals of *Millepora alcicornis*, as observed by the former author while stationed at Bermuda many years ago. The figures differ from those of Agassiz in arranging the tentacles regularly in whorls of four, and the authors conclude that Millepora is probably an Alcyonarian. The arrangement of tentacles is certainly quite unusual in the Alcyonaria, admitting the correctness of General Nelson's figures. In November, 1875, a paper by Mr. Moseley of the Challenger expedition was read before the Royal Society,§ in which the author reported observations on Millepora at Bermuda and elsewhere. The observations seem to have been quite unsatisfactory, and the author at that time ventured no conclusion from them. He was, however, more fortunate at Tahiti; and his paper read before the Royal Society in April, 1876,‖ gives the results of a more complete and satisfactory series of observations on the genus in question than has been made by any other author. His conclusions agree substantially with those of Agassiz.

In the winter of 1876–7, the writer spent some weeks in Bermuda, residing for a part of the time at Flats Village, on the shore of Harrington Sound. The abundance of Millepora in the shallow water of that beautiful lagoon afforded excellent opportunity for an investigation of the animals. In this work,

* This Journal, II, xxvi, 140. † Ibid, III, iii, 187.

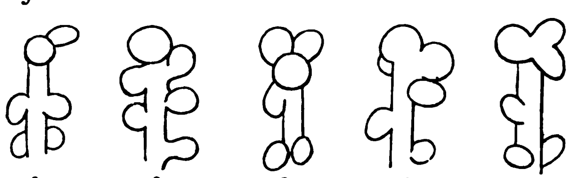
‡ Ann. and Mag. Nat. Hist., xvii, 354.

§ Philosophical Transactions, clxvi, 91: abstract in Ann. and Mag. Nat. Hist., xvii, 147.

‖ Phil. Trans., clxvii, 117; abstract in Ann. and Mag. Nat. Hist., xviii, 178.

the writer was favored with the kind assistance of Mr. G. Brown Goode, of the Smithsonian Institution. Our experience enabled us to appreciate the difficulty which observers have always found in the extreme shyness of the animals. Great care was taken in collecting the animals to avoid subjecting them to any more of a shock than was necessary. In accordance with a suggestion of Professor Verrill, we were careful not to have the specimens out of water for an instant either in collecting them or in the subsequent manipulation. Specimens were collected at various hours of the day, and examined at about all hours of the day and night. Only once were we favored with a sight of the zooids in expansion. Though that observation was far from being as satisfactory as could be desired, the writer has thought it might be worth while to give an account of it; for, on a subject so important and presenting such difficulties to every observer, every scrap of observation is probably worth saving.

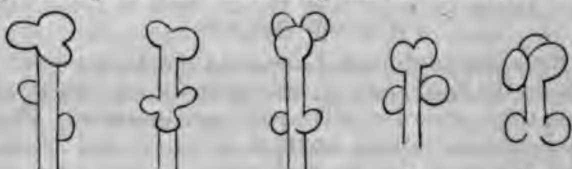
The zooids which we saw in expansion showed generally a pretty regular whorl of tentacles at the summit. There seemed to be indications of a tendency to a grouping of the tentacles in one or more whorls below the one at the summit. But these lower whorls were not at all regularly developed, and in some cases the tentacles were scattered singly without any recognizable arrangement in successive whorls. Where an approximation to a whorled arrangement could be recognized, the number of tentacles in a whorl was generally four, but appeared to be sometimes three. As regards the arrangement of the tentacles, our observation is therefore substantially in agreement with those of Agassiz and Moseley. We feel very confident that the tentacles are not in uniform and regular whorls of four, as figured by Nelson and Duncan.



1. 2. 3. 4. 5.

The accompanying figures, 1 to 20, represent the outlines of several zooids in the various positions in which they chanced to present themselves. The drawings were made hastily while the specimens were under examination. It is needless to remark that they make no pretension to any artistic character. Whatever value they may have arises from the fact of a conscientious endeavor to draw exactly the outlines which were seen, not a line being added hypothetically or inferentially. Figures

1–16 represent zooids seen more or less nearly in profile; figures 17–20 zooids seen from above. Figures 5, 6, 8, 14, 15 were drawn by Mr. Goode; the remainder by the writer. The drawings testify to the entire agreement between the two



6. 7. 8. 9. 10.

observers. The zooids seen by us appear to have been of the mouthless kind. Moseley has noticed the fact that these expand much more readily than the others. Our observations were made partly with a two-inch, but chiefly with a one-inch objective.

11. 12. 13. 14. 15.

Some attempts were made to study the zooids by means of decalcified specimens, previously treated with picric acid and alcohol; a preliminary treatment with picric acid and subsequent removal to alcohol having been shown by experiments

16. 17. 18. 19. 20.

undertaken by members of the United States Fish Commission, in 1874, to be remarkably effective in preserving the delicate tissues of Hydrozoa. We did not succeed in obtaining by this means any zooids in satisfactory condition. The specimens, however, prepared as above stated, and subsequently mounted in glycerine jelly, show well some details of structure, particularly the lasso-cells with extraordinarily long thread, figured by Moseley.* Moseley's figure of a lasso-cell from *Millepora nodosa* illustrates well the character of those in *Millepora alcicornis*, though in the latter the spinous portion is somewhat nearer the base of the thread. The length of the thread in the longest of our specimens is about ·027 inch.

* Philosophical Transactions, clxvii, pl. II, fig. 1.

ART. XVII. — *Forest Geography and Archæology; a Lecture delivered before the Harvard University Natural History Society,* April 18, 1878; by ASA GRAY.

[Continued from p. 94.]

THE difference in the composition of the Atlantic and Pacific forests is not less marked than that of the climate and geographical configuration to which the two are respectively adapted.

With some very notable exceptions, the forests of the whole northern hemisphere in the temperate zone (those that we are concerned with) are mainly made up of the same or similar *kinds.* Not of the same species; for rarely do identical trees occur in any two or more widely separated regions. But all round the world in our zone, the woods contain *Pines* and *Firs* and *Larches, Cypresses* and *Junipers, Oaks* and *Birches, Willows* and *Poplars, Maples* and *Ashes* and the like. Yet with all these family likenesses throughout, each region has some peculiar features, some trees by which the country may at once be distinguished.

Beginning by a comparison of our Pacific with our Atlantic forest, I need not take the time to enumerate the trees of the latter, as we all may be supposed to know them, and many of the genera will have to be mentioned in drawing the contrast to which I invite your attention. In this you will be impressed most of all, I think, with the fact that the greater part of our familiar trees are "conspicuous by their absence" from the Pacific forest.

For example, it has no Magnolias, no Tulip-tree, no Papaw, no Linden or Basswood, and is very poor in Maples; no Locust-trees—neither Flowering Locust nor Honey Locust—nor any Leguminous tree; no Cherry large enough for a timber-tree, like our wild Black Cherry; no Gum-trees (Nyssa nor Liquidambar), nor Sorrel-tree, nor Kalmia; no Persimmon, or Bumelia; not a Holly; only one Ash that may be called a timber-tree; no Catalpa, or Sassafras; not a single Elm, nor Hackberry; not a Mulberry, nor Planer-tree, nor Maclura; not a Hickory, nor a Beech, nor a true Chestnut, nor a Hornbeam; barely one Birch tree, and that only far north, where the differences are less striking. But as to Coniferous trees, the only missing type is our Bald Cypress, the so-called Cypress of our southern swamps, and that deficiency is made up by other things. But as to ordinary trees, if you ask what takes the place in Oregon and California of all these missing kinds, which are familiar on our side of the continent, I must answer, nothing, or nearly nothing. There is the *Madroña* (Arbutus) instead of our Kalmia (both really trees in some places); and

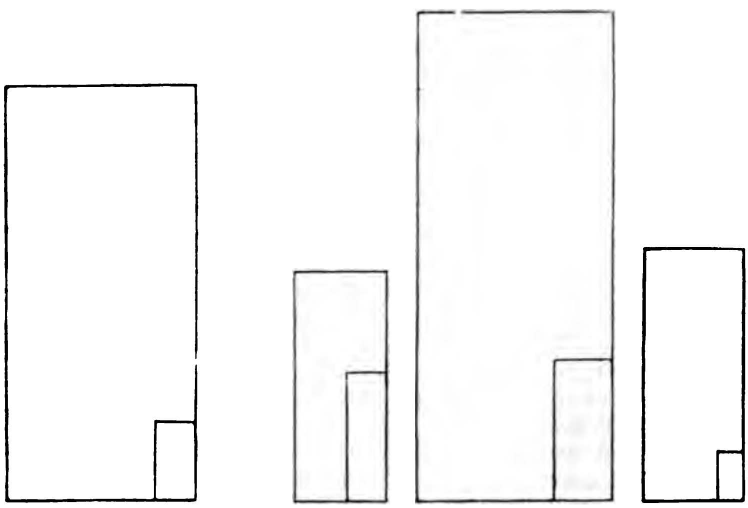
there is the California Laurel instead of our southern Red Bay tree. Nor in any of the genera common to the two does the Pacific forest equal the Atlantic in species. It has not half as many Maples, nor Ashes, nor Poplars, nor Walnuts, nor Birches, and those it has are of smaller size and inferior quality; it has not half as many Oaks; and these and the Ashes are of so inferior economical value, that (as we are told) a passable wagon-wheel cannot be made of California wood, nor a really good one in Oregon.

This poverty of the western forest in species and types may be exhibited graphically, in a way which cannot fail to strike the eye more impressively than when we say that, whereas the Atlantic forest is composed of 66 genera and 155 species, the Pacific forest has only 31 genera and 78 species.* In the appended diagrams, the short side of the rectangle is proportional to the number of genera, the long side to the number of species.

Now the geographical areas of the two forests are not very different. From the Gulf of Mexico to the Gulf of St. Lawrence about twenty degrees of latitude intervene. From the southern end of California to the peninsula of Alaska there are twenty-eight degrees, and the forest on the coast runs some degrees north of this; the length may therefore make up for the comparative narrowness of the Pacific forest region. How can so meagre a forest make so imposing a show? Surely not by the greater number and size of its individuals, so far as deciduous (or more correctly non-coniferous) trees are concerned; for on the whole they are inferior to their eastern brethren in size if not in number of individuals. The reason is, that a larger proportion of the genera and species are coniferous trees; and these, being evergreen (except the Larches), of aspiring port and eminently gregarious habit, usually dominate where they occur. While the east has almost three times as many genera and four times as many species of non-coniferous trees as the west, it has slightly fewer genera and almost one-half fewer species of coniferous trees than the west. That is, the Atlantic coniferous forest is represented by 11 genera and 25 species; the Pacific by 12 genera and 44 species. This relative preponderance may also be expressed by the diagrams, in which the smaller enclosed rectangles, drawn on the same scale, represent the coniferous portions of these forests.

* We take in only timber trees, or such as attain in the most favorable localities to a size which gives them a clear title to the arboreous rank. The subtropical southern extremity and Keys of Florida are excluded. So also are one or two trees of the Arizonian region which may touch the evanescent southern borders of the Californian forest. In counting the Coniferous genera, Pinus, Larix, Picea, Abies and Tsuga are admitted to this rank, but Cupressus and Chamæcyparis are taken as one genus.

Indeed, the Pacific forest is made up of conifers, with non-coniferous trees as occasional undergrowth or as scattered individuals, and conspicuous only in valleys or in the sparse tree-growth of plains, on which the oaks at most reproduce the features of the "oak openings" here and there bordering the Mississippi prairie region. Perhaps the most striking contrast between the west and the east, along the latitude usually traversed, is that between the spiry evergreens which the traveler leaves when he quits California, and the familiar woods of various-hued round-headed trees which give him the feeling of home when he reaches the Mississippi. The Atlantic forest is particularly rich in these, and is not meagre in coniferous trees. All the glory of the Pacific forest is in its coniferous trees: its desperate poverty in other trees appears in the annexed diagram.



1. 2. 3. 4.

1. Atlantic American Forest. 3. Japan-Manchurian Forest.
2. Pacific American Forest. 4. European Forest.

These diagrams are made more instructive, and the relative richness of the forests round the world in our latitude is most simply exhibited, by adding two or three similar ones. Two will serve, one for Europe, the other for N. E. Asia. A third would be the Himalay-Altaian region, geographically intermediate between the other two as the Arizona-Rocky Mountain district is between our eastern and western. Both are here left out of view, partly for the same, partly for special reasons pertaining to each, which I must not stop to explain. These four marked specimens will simply and clearly exhibit the general facts.

Keeping as nearly as possible to the same scale, we may count the indigenous forest trees of all Europe at 33 genera and 85 species. And those of the Japan-Manchurian region, of very much smaller geographical area, at 66 genera and 168 species. I here include in it only Japan, Eastern Manchuria, and the adjacent borders of China. The known species of trees must be rather roughly determined; but the numbers here given are not exaggerated, and are much more likely to be sensibly increased by further knowledge than are those of any of the other regions. Properly to estimate the surpassing richness of this Japan-Manchurian forest, the comparative smallness of geographical area must come in as an important consideration.

To complete the view, let it be noted that the division of these forests into coniferous and non-coniferous is, for the

European non-coniferous,	26 genera,	68 species.
" coniferous,	7 "	17 "
	33 "	85 "
Japan-Manchurian non-coniferous,	47 genera,	123 species.
" coniferous,	19 "	45 "
	66 "	168 "

In other words, a narrow region in Eastern Asia contains twice as many genera and about twice as many species of indigenous trees as are possessed by all Europe; and as to coniferous trees, the former has more genera than the latter has species, and over twice and a half as many species.

The only question about the relation of these four forest regions, as to their component species, which we can here pause to answer, is to what extent they contain trees of identical species. If we took the shrubs, there would be a small number, if the herbs a very considerable number, of species common to the two New World and to the two Old World areas respectively, at least to their northern portions, even after excluding arctic-alpine plants. The same may be said, in its degree, of the North European flora compared with the Atlantic North American, of the Northeast Asiatic compared with the northern part of the Pacific North American, and also in a peculiar way (which I have formerly pointed out and shall have soon to mention) of the Northeastern Asiatic flora in its relations to the Atlantic North American. But as to the forest trees there is very little community of species. Yet this is not absolutely wanting. The Red Cedar (*Juniperus Virginiana*) among coniferous trees, and *Populus tremuloides* among the deciduous, extend across the American continent specifically unchanged, though hardly developed as forest trees on the Pacific side.

There are probably, but not certainly, one or two instances on the northern verge of these two forests. There are as many in which eastern and western species are suggestively similar. The Hemlock-Spruce of the Northern Atlantic States, and the Yew of Florida are extremely like corresponding trees of the Pacific forest; indeed the Yew-trees of all four regions may come to be regarded as forms of one polymorphous species. The White Birch of Europe and that of Canada and New England are in similar case; and so is the common Chestnut (in America confined to the Atlantic States), which on the other side of the world is also represented in Japan. A link in the other direction is seen in one spruce tree (called in Oregon Menzies Spruce) which inhabits Northeast Asia, while a peculiar form of it represents the species in the Rocky Mountains.

But now other and more theoretical questions come to be asked, such as these:

Why should our Pacific forest region, which is rich and in some respects unique in coniferous, be so poor in deciduous trees?

Then the two *Big-trees*, Sequoias, as isolated in character as in location,—being found only in California, and having no near relatives any where,—how came California to have them?

Such relatives as the Sequoias have are also local, peculiar, and chiefly of one species to each genus. Only one of them is American, and that solely eastern, the Taxodium of our Atlantic States and the plateau of Mexico. The others are Japanese and Chinese.

Why should trees of six related genera, which will all thrive in Europe, be restricted naturally, one to the eastern side of the American continent, one genus to the western side and very locally, the rest to a small portion of the eastern border of Asia?

Why should coniferous trees most affect and preserve the greatest number of types in these parts of the world?

And why should the Northeast Asian region have, in a comparatively small area, not only most coniferous trees, but a notably larger number of trees altogether than any other part of the northern temperate zone? Why should its only and near rival be in the antipodes, namely, here in Atlantic North America? In other words why should the Pacific and the European forests be so poor in comparison, and why the Pacific poorest of all in deciduous, yet rich in coniferous trees?

The first step toward an explanation of the superior richness in trees of these antipodal regions, is to note some striking similarities of the two, and especially the number of peculiar types which they divide between them. The ultimate conclusion may at length be ventured, that this richness is normal, and that what we really have to explain is the absence of so many

forms from Europe on the one hand, from Oregon and California on the other. Let me recall to mind the list of kinds (i. e. genera) of trees which enrich our Atlantic forest but are wanting to that of the Pacific. Now almost all these recur, in more or less similar but not identical species, in Japan, North China, etc. Some of them are likewise European, but more are not so. Extending the comparison to shrubs and herbs, it more and more appears, that the forms and types which we count as peculiar to our Atlantic region, when we compare them, as we first naturally do, with Europe and with our West, have their close counterparts in Japan and North China; some in identical species (especially among the herbs), often in strikingly similar ones, not rarely as sole species of peculiar genera or in related generic types. I was a very young botanist when I began to notice this; and I have from time to time made lists of such instances. Evidences of this remarkable relationship have multiplied year after year, until what was long a wonder has come to be so common that I should now not be greatly surprised if a Sarracenia or a Dionæa, or their like, should turn up in Eastern Asia. Very few of such isolated types remain without counterparts. It is as if Nature, when she had enough species of a genus to go round, dealt them fairly, one at least to each quarter of our zone; but when she had only two of some peculiar kind gave one to us and the other to Japan, Manchuria, or the Himalayas; when she had only one, divided these between the two partners on the opposite side of the table. The result, as to the trees, is seen in these four diagrams. As to number of species generally, it cannot be said that Europe and Pacific North America are at all in arrears. But as to trees, either the contrasted regions have been exceptionally favored, or these have been hardly dealt with. There is, as I have intimated, some reason to adopt the latter alternative.

We may take it for granted that the indigenous plants of any country, particularly the trees, have been selected by climate. Whatever other influences or circumstances have been brought to bear upon them, or the trees have brought to bear on each other, no tree could hold its place as a member of any forest or flora which is not adapted to endure even the extremes of the climate of the region or station. But the character of the climate will not explain the remarkable paucity of the trees which compose the indigenous European forest. That is proved by experiment, sufficiently prolonged in certain cases to justify the inference. Probably there is no tree of the northern temperate zone which will not flourish in some part of Europe. Great Britain alone can grow double or treble the number of trees that the Atlantic States can. In all the latter

we can grow hardly one tree of the Pacific coast. England supports all of them, and all our Atlantic trees also, and likewise the Japanese and North Siberian species, which do thrive here remarkably in some part of the Atlantic coast, especially the cooler-temperate ones. The poverty of the European sylva is attributable to the absence of our Atlantic American types, to its having no Magnolia, Liriodendron, Asimina, Negundo, no Æsculus, none of that rich assemblage of Leguminous trees represented by Locusts, Honey-Locusts, Gymnocladus, and Cladrastis (even its Cercis, which is hardly European, is like the Californian one mainly a shrub); no Nyssa, nor Liquidambar; no Ericaceæ rising to a tree; no Bumelia, Catalpa, Sassafras, Osage Orange, Hickory, or Walnut; and as to Conifers, no Hemlock Spruce, Arbor-vitæ, Taxodium, nor Torreya. As compared with Northeastern Asia, Europe wants most of these same types, also the Ailantus, Gingko, and a goodly number of coniferous genera. I cannot point to any types tending to make up the deficiency, that is, to any not either in East North America or in Northeast Asia, or in both. Cedrus, the true Cedar, which comes near to it, is only North African and Asian. I need not say that Europe has no Sequoia, and shares no special type with California.

Now the capital fact is, that many and perhaps almost all of these genera of trees were well represented in Europe throughout the later Tertiary times. It had not only the same generic types, but in some cases even the same species, or what must pass as such, in the lack of recognizable distinctions between fossil remains and living analogues. Probably the European Miocene forest was about as rich and various as is ours of the present day, and very like it. The Glacial period came and passed, and these types have not survived there, nor returned. Hence the comparative poverty of the existing European sylva, or at least, the probable explanation of the absence of those kinds of trees which make the characteristic difference.

Why did these trees perish out of Europe but survive in America and Asia? Before we enquire how Europe lost them, it may be well to ask, how it got them. How came these American trees to be in Europe? And among the rest, how came Europe to have Sequoias, now represented only by our two Big trees of California? It actually possessed two species and more; one so closely answering to the Redwood of the Coast Ranges, and another so very like the *Sequoia gigantea* of the Sierra Nevada, that, if such fossil twigs with leaves and cones had been exhumed in California instead of Europe, it would confidently be affirmed that we had resurrected the veritable ancestors of our two giant trees. Indeed, so it may probably be. "*Cœlum non animam mutant,*" etc., may be

applicable even to such wide wanderings and such vast intervals of time. If the specific essence has not changed, and even if it has suffered some change, genealogical connection is to be inferred in all such cases.

That is, in these days it is taken for granted that individuals of the same species, or with a certain likeness throughout, had a single birthplace, and are descended from the same stock, no matter how widely separated they may have been either in space or time, or both. The contrary supposition may be made, and was seriously entertained by some not very long ago. It is even supposable that plants and animals originated where they now are, or where their remains are found. But this is not science: in other words it is not conformable to what we now know, and is an assertion that scientific explanation is not to be sought.

Furthermore, when species of the same genus are not found almost everywhere, they are usually grouped in one region, as are the Hickories in the Atlantic States, the Asters and Golden-rods in North America and prevailingly on the Atlantic side, the Heaths in Western Europe and Africa. From this we are led to the inference that all species closely related to each other have had a common birth-place and origin. So that, when we find individuals of a species or of a group widely out of the range of their fellows we wonder how they got there. When we find the same species all round the hemisphere, we ask how this dispersion came to pass.

Now, a very considerable number of species of herbs and shrubs, and a few trees, of the temperate zone are found all round the northern hemisphere; many others are found part way round,—some in Europe and Eastern Asia; some in Europe and our Atlantic States: many, as I have said, in the Atlantic States and Eastern Asia;—fewer (which is curious) common to Pacific States and Eastern Asia, nearer though these countries be.

We may set it down as useless to try to account for this distribution by causes now in operation and opportunities now afforded, i. e., for distribution across oceans by winds and currents, and birds. These means play their part in dispersion from place to place, by step after step, but not from continent to continent, except for few things and in a subordinate way.

Fortunately we are not obliged to have recourse to overstrained suppositions of what might possibly have occurred now and then, in the lapse of time, by the chance conveyance of seeds across oceans, or even from one mountain to another. The plants of the top of the White Mountains and of Labrador are mainly the same; but we need not suppose that it is so because birds have carried seeds from the one to the other.

I take it that the true explanation of the whole problem

comes from a just general view, and not through piecemeal suppositions of chances. And I am clear that it is to be found by looking to the north, to the state of things at the arctic zone,—first, as it now is, and then as it has been.

North of our forest-regions comes the zone unwooded from cold, the zone of arctic vegetation. In this, as a rule, the species are the same round the world; as exceptions, some are restricted to a part of the circle.

The polar projection of the earth down to the northern tropic, as here exhibited, shows to the eye—as our maps do not—how all the lands come together into one region, and how natural it may be for the same species, under homogeneous conditions, to spread over it. When we know, moreover, that sea and land have varied greatly since these species existed, we may well believe that any ocean-gaps, now in the way of equable distribution, may have been bridged over. There is now only one considerable gap.

What would happen if a cold period were to come on from the north, and were very slowly to carry the present arctic climate, or something like it, down far into the temperate zone? Why, just what has happened in the Glacial period, when the refrigeration somehow pushed all these plants before it down to Southern Europe, to Middle Asia, to the middle and southern part of the United States; and, at length receding, left some parts of them stranded on the Pyrenees, the Alps, the Appenines, the Caucasus, on our White and Rocky Mountains, or, wherever they could escape the increasing warmth as well by ascending mountains as by receding northward at lower levels. Those that kept together at a low level, and made good their retreat, form the main body of present arctic vegetation. Those that took to the mountains had their line of retreat cut off, and hold their positions on the mountain-tops under cover of the frigid climate due to elevation. The conditions of these on different continents or different mountains are similar, but not wholly alike. Some species proved better adapted to one, some to another, part of the world; where less adapted, or less adaptable, they have perished; where better adapted, they continue,—with or without some change;—and hence the diversification of alpine plants, as well as the general likeness through all the northern hemisphere.

All this exactly applies to the temperate zone vegetation, and to the trees that we are concerned with. The clew was seized when the fossil botany of the high arctic regions came to light: when it was demonstrated that in the times next preceding the Glacial period—in the latest Tertiary—from Spitzbergen and Iceland to Greenland and Kamtschatka, a climate like that we now enjoy prevailed, and forests like those of New

England and Virginia, and of California, clothed the land. We infer the climate from the trees; and the trees give sure indications of the climate.

I had divined and published the explanation long before I knew of the fossil plants. These, since made known, render the inference sure, and give us a clear idea of just what the climate was. At the time we speak of, Greenland, Spitzbergen and our arctic sea-shore, had the climate of Pennsylvania and Virginia now. It would take too much time to enumerate the sorts of trees that have been identified by their leaves and fruits in the arctic later Tertiary deposits.

I can only say, at large, that the same species have been found all round the world; that the richest and most extensive finds are in Greenland; that they comprise most of the sorts which I have spoken of, as American trees which once lived in Europe,—Magnolias, Sassafras, Hickories, Gum-trees, our identical Southern Cypress (for all we can see of difference), and especially *Sequoias*, not only the two which obviously answer to the two Big-trees now peculiar to California, but several others; that they equally comprise trees now peculiar to Japan and China, three kinds of Gingko-trees, for instance, one of them not evidently distinguishable from the Japan species which alone survives; that we have evidence, not merely of Pines and Maples, Poplars, Birches, Lindens, and whatever else characterize the temperate-zone forests of our era, but also of particular species of these, so like those of our own time and country, that we may fairly reckon them as the ancestors of several of ours. Long genealogies always deal more or less in conjecture; but we appear to be within the limits of scientific inference when we announce that our existing temperate trees came from the north, and within the bounds of nigh probability when we claim not a few of them as the originals of present species. Remains of the same plants have been found fossil in our temperate region, as well as in Europe.

Here, then, we have reached a fair answer to the question how the same or similar species of our trees came to be so dispersed over such widely separated continents. The lands all diverge from a polar center, and their proximate portions—however different from their present configuration and extent, and however changed at different times—were once the home of those trees, where they flourished in a temperate climate. The cold period which followed, and which doubtless came on by very slow degrees during ages of time, must have long before its culmination have brought down to our latitudes, with the similar climate, the forest they possess now, or rather the ancestors of it. During this long (and we may believe first) occupancy of Europe and the United States, were deposited in pools and shallow

waters the cast leaves, fruits, and occasionally branches, which are imbedded in what are called Miocene Tertiary or later deposits, most abundant in Europe, from which the American character of the vegetation of the period is inferred. Geologists give the same name to these beds, in Greenland and Southern Europe, because they contain the remains of identical and very similar species of plants; and they used to regard them as of the same age on account of this identity. But in fact this identity is good evidence that they cannot be synchronous. The beds in the lower latitudes must be later, and were forming when Greenland probably had very nearly the climate which it has now.

Wherefore the high, and not the low, latitudes must be assumed as the birth-place of our present flora;* and the present arctic vegetation is best regarded as a derivative of the temperate. This flora, which when circumpolar was as nearly homogeneous round the high latitudes as the arctic vegetation is now, when slowly translated into lower latitudes, would preserve its homogeneousness enough to account for the actual distribution of the same and similar species round the world, and for the original endowment of Europe with what we now call American types. It would also vary or be selected from by the increasing differentiation of climate in the divergent continents, and on their different sides, in a way which might well account for the present diversification. From an early period, the system of the winds, the great ocean currents (however they may have oscillated north and south), and the general proportions and features of the continents in our latitude (at least of the American continent) were much the same as now, so that species of plants, ever so little adapted or predisposed to cold winters and hot summers, would abide and be developed on the eastern side of continents, therefore in the Atlantic United States and in Japan and Manchuria; those with preference for milder winters would incline to the western sides; those disposed to tolerate dryness would tend to interiors, or to regions lacking summer rain. So that, if the same thousand species were thrust promiscuously into these several districts, and carried slowly onward in the way supposed, they would inevitably be sifted in such a manner that the survival of the fittest for each district might explain the present diversity.

Besides, there are re-siftings to take into the account. The Glacial period or refrigeration from the north, which at its inception forced the temperate flora into our latitude, at its culmination must have carried much or most of it quite beyond.

* This takes for granted, after Nordenskiöld, that there was no preceding Glacial period, as neither paleontology nor the study of arctic sedimentary strata afford any evidence of it. Or if they were any, it was too remote in time to concern the present question.

To what extent displaced, and how far superseded by the vegetation which in our day borders the ice, or by ice itself, it is difficult to form more than general conjectures—so different and conflicting are the views of geologists upon the Glacial period. But upon any, or almost any, of these views, it is safe to conclude that temperate vegetation, such as preceded the refrigeration and has now again succeeded it, was either thrust out of Northern Europe and the Northern Atlantic States, or was reduced to precarious existence and diminished forms. It also appears that, on our own continent at least, a milder climate than the present, and a considesable submergence of land, transiently supervened at the north, to which the vegetation must have sensibly responded by a northward movement, from which it afterward receded.

All these vicissitudes must have left their impress upon the actual vegetation, and particularly upon the trees. They furnish probable reason for the loss of American types sustained by Europe.

I conceive that three things have conspired to this loss. First, Europe, hardly extending south of latitude 40°, is all within the limits generally assigned to severe glacial action. Second, its mountains trend east and west, from the Pyrenees to the Carpathians and the Caucasus beyond, near its southern border; and they had glaciers of their own, which must have begun their operations, and poured down the northward flanks, while the plains were still covered with forest on the retreat from the great ice-wave coming from the north. Attacked both on front and rear, much of the forest must have perished then and there. Third, across the line of retreat of those which may have flanked the mountain-ranges, or were stationed south of them, stretched the Mediterranean, an impassable barrier. Some hardy trees may have eked out their existence on the northern shore of the Mediterranean and the Atlantic coast. But we doubt not, Taxodium and Sequoias, Magnolias and Liquidambars, and even Hickories and the like were among the missing. Escape by the east, and rehabilitation from that quarter until a very late period, was apparently prevented by the prolongation of the Mediterranean to the Caspian, and thence to the Siberian ocean. If we accept the supposition of Nordenskiöld, that anterior to the Glacial period, Europe was "bounded on the south by an ocean extending from the Atlantic over the present deserts of Sahara and Central Asia to the Pacific," all chance of these American types having escaped from or re-entered Europe from the south and east, is excluded. Europe may thus be conceived to have been for a time somewhat in the condition in which Greenland is now, and, indeed to have been connected with Greenland in this or in earlier times. Such a

junction, cutting off access of the Gulf Stream to the polar sea, would, as some think, other things remaining as they are, almost of itself give glaciation to Europe. Greenland may be referred to, by way of comparison, as a country which, having undergone extreme glaciation, bears the marks of it in the extreme poverty of its flora, and in the absence of the plants to which its southern portion, extending six degrees below the arctic circle, might be entitled. It ought to have trees, and might support them. But since destruction by glaciation, no way has been open for their return. Europe fared much better, but suffered in its degree in a similar way.

Turning for a moment to the American continent for a contrast, we find the land unbroken and open down to the tropic, and the mountains running north and south. The trees, when touched on the north by the on-coming refrigeration, had only to move their southern border southward, along an open way, as far as the exigency required; and there was no impediment to their due return. Then the more southern latitude of the United States gave great advantage over Europe. On the Atlantic border, proper glaciation was felt only in the northern part, down to about latitude 40°. In the interior of the country, owing doubtless to greater dryness and summer heat, the limit receded greatly northward in the Mississippi Valley, and gave only local glaciers to the Rocky Mountains; and no volcanic outbreaks or violent changes of any kind have here occurred since the types of our present vegetation came to the land. So our lines have been cast in pleasant places, and the goodly heritage of forest trees is one of the consequences.

The still greater richness of Northeast Asia in arboreal vegetation may find explanation in the prevalence of particularly favorable conditions, both ante-glacial and recent. The trees of the Miocene circumpolar forest appear to have found there a secure home; and the Japanese islands, to which most of these trees belong, must be remarkably adapted to them. The situation of these islands—analogous to that of Great Britain, but with the advantage of lower latitude and greater sunshine—their ample extent north and south, their diversified configuration, their proximity to the great Pacific gulf-stream, by which a vast body of warm water sweeps along their accentuated shores, and the comparatively equable diffusion of rain throughout the year, all probably conspire to the preservation and development of an originally ample inheritance.

The case of the Pacific forest is remarkable and paradoxical. It is, as we know, the sole refuge of the most characteristic and wide spread type of Miocene Coniferæ, the Sequoias; it is rich in coniferous types beyond any country except Japan; in its gold-bearing gravels are indications that it possessed, seemingly

down to the very beginning of the Glacial period, Magnolias and Beeches, a true Chestnut, Liquidambar, Elms, and other trees now wholly wanting to that side of the continent, though common both to Japan and to Atlantic North America.* Any attempted explanation of this extreme paucity of the usually major constituents of forest, along with a great development of the minor, or coniferous, element, would take us quite too far, and would bring us to mere conjectures.

Much may be attributed to late glaciation;† something to the tremendous outpours of lava which, immediately before the period of refrigeration, deeply covered a very large part of the forest area; much to the narrowness of the forest belt, to the want of summer rain, and to the most unequal and precarious distribution of that of winter.

Upon all these topics questions open which we are not prepared to discuss. I have done all that I could hope to do in one lecture if I have distinctly shown that the races of trees, like the races of men, have come down to us through a pre-historic (or pre-natural-historic) period; and that the explanation of the present condition is to be sought in the past, and traced in vestiges, and remains, and survivals; that for the vegetable kingdom also there is a veritable Archæology.

ART. XVIII.—*Notes on Antimony Tannate;* by ELLEN SWALLOW RICHARDS and ALICE W. PALMER.

IN the course of some work on the determination of tannic acid, we tried Gerland's method of direct estimation by means of a standard solution of tartar emetic in presence of ammonium chloride. Gerland's formula, in which the old atomic weights are used (Zeitschrift für Analyse, 1863, ii, page 419), is given as $SbO_3(C_{18}H_8O_{12})_3$ [or in the new nomenclature $Sb_2O_3(C_{18}H_{16}O_{12})_3$] which requires

Sb, 15·60 per cent, C, 41·43 per cent, H, 3·07 per cent.

The formula that we have been led to adopt, is $Sb_2(C_{14}H_8O_9)_2+6H_2O$ which requires

Sb, 18·59 per cent, C, 38·41 per cent, H, 2·74 per cent,

in which tannic acid is considered as di-gallic acid,‡ with, possi-

* See, especially, Report on the Fossil Plants of the auriferous gravel deposits of the Sierra Nevada, by L. Lesquereux; Mem. Mus. Comp. Zoology, vi,. no 2.—Determinations of fossil leaves, &c., such as these, may be relied on to this extent by the general botanist, however wary of specific and many generic identifications. These must be mainly left to the expert in fossil botany.

† Sir Joseph Hooker, in an important lecture delivered to the Royal Institution of Great Britain, April 12, insists much on this.

‡ H. Schiff, Bull. Soc. Chem., II, xvi, 198.

bly, three phenol H's replaced by Sb as well as three acid H's. This formula is deduced from the following analyses of antimony tannate. All the tannates described in this paper were prepared in the same manner. The solution, containing five to ten grams of tannic acid per liter, was heated to 60° C. in a water bath. Tartar emetic in strong solution was added, then 30 c.c. of ammonium acetate per liter. After the whole was shaken and allowed to settle, it was filtered and dried at 100° C. to 105° C. for three or four days in an ordinary air-bath. The bulky, yellowish-white, gelatinous precipitate at first formed became, when dried, yellowish to reddish-brown, transparent, amorphous, and broken into small angular fragments.

Antimony Tannates.

	Sb. Per cent.	C. Per cent.	H. Per cent.
From purified tannin	20·6	37·38	2·91
		37·53	2·98
		37·51	2·78
From unfiltered tannin		37·95	2·71
From filtered tannin		39·30	2·86
From nutgalls	20·5	38·32	2·88
		38·47	2·81
		38·14	2·92
From sumac, No. I		39·60	2·70
II		39·54	2·74
III	20·1	40·51	2·92

The antimony was determined as a sulphide, and the calculated results are probably a little too high.

As to the process of titration, our first experience coincided with the statement of Gauhe (Zeitschrift für Analyse, 1863, iii, page 122), that the end of the reaction was difficult to seize, and that the dilute solutions remained turbid. Even after we found an indicator, the process in our hands gave varying results with varying quantities of ammonium chloride and with different proportions of water.

We then made a series of tests with other substances, viz: alum, salts of sodium, etc., as precipitating agents. The one chosen as a result of these tests was ammonium acetate, prepared by mixing in the right proportion glacial acetic acid and strong ammonia water of known strengths.* 1 c.c. of this preparation added for every 25 or 30 c.c. of the total bulk, will give a clear, supernatant liquid after standing a few minutes.

Without stating in detail the steps of the investigation, we give our process as we now use it.

* We used acetic acid containing 95 per cent $C_2H_4O_2$ and ammonia containing 27 per cent NH_3, making about 600 grams $NH_4C_2H_3O_2$ for one liter of the solution.

The weighed quantity of the substance in which the tannic acid is to be estimated is taken in sufficient quantity to allow of, at least, three aliquot parts, each portion of 50 to 100 c.c. containing ·100 to ·300 grams of tannic acid. After the solution, made by digestion with water, is made up to a known bulk, three or four portions are measured out and set in a water bath to be heated to 50° or 60° C. The standard solution of tartar emetic contains 6·730 grams per liter of the $C_4H_4KSbO_7$ salt dried at 100° C. 1 c.c. is considered to correspond to ·010 gram of tannic acid. Gerland's formula would require 5·222 grams per liter for the same value.

The estimation is facilitated by obtaining a maximum and a minimum point at the first reading, as one portion is settling while the other is being treated; therefore tartar emetic is added from a burette to one portion in excess of the probable quantity required, and to another in less amount. The antimony tannate is then precipitated by the requisite number of cubic centimeters of ammonium acetate, and allowed to settle. A drop of the clear liquid is added to a drop of sodium hyposulphite on a hot porcelain plate, and if the tartar emetic has been added in excess, the deep orange color of the antimony sulphide will at once appear. When this point is reached by successive additions of the standard solution to the minimum portion, we add to a third portion the estimated quantity, and test the clear liquid as a check on the loss occasioned by taking out several drops.

We have found it easier to carry the titration to a decided orange tint, and to subtract ·5 c.c. of tartar emetic solution for 100 c.c. of liquid, rather than to try to seize the first faint tinge, as most of the substances to be titrated contain coloring matter which give a yellowish or reddish tint, but not an orange color.

Gerland states that neither gallic acid nor the coloring matter contained in certain substances affects the results. This seems to be true so far as gallic acid is concerned, but the discussion of the relation of the coloring matter to the precipitate, together with the results of our titrations and combustions of antimony tannate from hemlock bark, oak bark, sweet-fern leaves, etc., must be reserved for a future paper.

Massachusetts Institute of Technology, Woman's Laboratory, July, 1878.

Art. XIX.—*On some Seleniocyanates; on the Electrolytic Estimation of Mercury; some Specific Gravity Determinations.* Being Parts VII, VIII and IX of Laboratory Notes from the University of Cincinnati; by F. W. Clarke, S.B., Professor of Chemistry.

VII. *On some Seleniocyanates.*

In 1855 Buckton discovered and described the double sulphocyanates of platinum.* Of these, the potassium salt is perhaps the one best known, partly because of its beauty, and partly because of the ease with which it may be prepared. Recently, my attention having been called to this compound, it occurred to me that it might be interesting to prepare the corresponding seleniocyanate. Accordingly I assigned the task to Mr. W. L. Dudley, a student in the University of Cincinnati, who had little difficulty in attaining to success.

When an alcoholic solution of potassium seleniocyanate is added to a similar solution of platinic chloride, a heavy reddish brown precipitate is immediately formed. This, upon boiling, becomes darker in color, and apparently in part dissolves. The filtered liquid deposits crystals of the new salt, mixed with a reddish sediment of selenium; and these, although they are slightly unstable, may be purified by recrystallization from alcohol. The crystals are usually very small; mere scales in fact; although on one occasion they separated out as regular six-sided tables, several millimeters in diameter. By reflected light they are nearly black; but by transmitted light, deep garnet red. Specific gravity, 3·377 at 10°·2, 3·378 at 12°·5. The weighings were made in benzol. Determinations of platinum and potassium came out as follows:

	Found.	Theory.
Potassium	8·57	8·61
Platinum	21·64	21·73

There is, therefore, no reasonable doubt that the new salt is represented by the formula $K_2Pt(CSeN)_6$, and that it is strictly analogous to Buckton's sulphocyanate.

An attempt to prepare gold salts resembling the sulphocyanates described by Cleve† was only partially successful. When alcoholic solutions of potassium seleniocyanate and neutral gold chloride are mixed, a red precipitate falls, which consists in large part of free selenium. The pale orange-yellow filtrate from this precipitate yields by spontaneous evaporation a crystalline crust, which under the microscope is seen to be made up chiefly of minute, deep red prisms. These crystals are so

* Chem. Soc. Quart. Journ., vii, 22. † Jahresbericht, 1865, p. 295.

very unstable that we could obtain but a very small quantity of them, and in a somewhat impure condition. They yielded 48·31 per cent of gold, whereas the salt $KAu(CSeN)_2$, analogous to the potassio-aurous sulphocyanate of Cleve, should contain but 43·94. As the new salt was prepared by a method precisely similar to that which gave Cleve his sulphocyanate, there can be little doubt that we had to deal with the corresponding seleniocyanate, mixed with free gold. If we had been able to command larger quantities of material, we might have been able to prepare the compound in a state more nearly approaching purity.

No seleniocyanate resembling Roesler's potassium chromosulphocyanate, $K_6Cr(CSN)_{12}$, $8H_2O$,* could be obtained. When aqueous solutions of chrome alum and potassium seleniocyanate are mixed, selenium is precipitated, and no trace of any double salt seems to be formed.

VIII. *On the Electrolytic estimation of Mercury.*

In 1865, Wolcott Gibbs published his well known method for the electrolytic estimation of copper.† More recently, Merrick has shown that a modification of the same process is applicable to nickel and to zinc.‡

Having occasion recently to make a number of copper determinations by this method, it naturally occurred to me that it might be extended still farther, especially to the cases of cadmium and mercury. With cadmium I was disappointed; but with mercury, successful. Cadmium may indeed be completely precipitated by electrolysis from an ammoniacal solution, but it comes down in a spongy, porous form, enclosing various impurities which cannot be readily washed out. Accordingly the results came out several per cent too high. The mercury, however, gave results in every respect satisfactory.

A solution of mercuric chloride, slightly acidulated with sulphuric acid, was placed in a platinum dish connected with the zinc pole of a six-cell Bunsen's bichromate battery. The wire from the carbon pole terminated in a thin slip of platinum foil, which dipped into the solution. At first, mercurous chloride was precipitated, but this by degrees was reduced to the metallic state, so that after an hour or so there remained in the dish a clean mass of mercury, covered by a solution in which ammonia failed to produce the slightest turbidity. When I poured off this clear acid solution the mercury became covered with a thin tarnished film, which at first annoyed me considerably. I soon found, however, that this annoyance could be avoided very easily. I simply drew off the solution from

* Journ. für Prakt. Chem., cii, 316. † This Journ. xxxix, 64.
‡ American Chemist, October, 1871; Chem. News, xxiv, 100, 172.

above the mercury by means of a pipette, and replaced it with clean water; doing this several times before disconnecting the platinum dish from the battery. Then, upon decanting the very feebly acid supernatant liquid, the metal remained perfectly bright and clean. It was only necessary after this to rinse thoroughly with pure water, then with alcohol, and lastly with ether, and to dry under the receiver of an air-pump. Two determinations made with mercuric chloride gave respectively 73·76 and 73·85 per cent of mercury. Theory 73·80. There are no difficulties in the process, and no appreciable sources of error. Although I have made actual determinations of mercury only with the chloride, I have tested other salts of the metal and have found that the precipitation is similarly perfect. In one instance I employed a solution of mercury containing a heavy precipitate of basic sulphate. This precipitate was readily and completely decomposed by the electric current, so that ultimately nothing but metallic mercury remained visible in the solution. In every case, mercurous compounds appear to be thrown down first, so that their final disappearance furnishes a sharp end reaction to indicate when the operation is complete.

IX. *Some Specific Gravity Determinations.*

The following specific gravity determinations represent work done by my students and myself during the school year 1877–1878. Those portions of the work which were entrusted to students were carried out under my immediate supervision, and every precaution was taken to ensure a fair degree of accuracy. The salts were all weighed in benzol, and the figures refer to water at its temperature of maximum density as unity.

To Mr. W. H. Creighton and Mr. E. F. Wittmann I assigned mercuric cyanide and some of its double compounds. For the cyanide itself, $HgCy_2$, we found a sp. gr. of 4·0262 at 12°, Creighton; 4·0026 at 22·2, Wittmann; and 4·0036, 14°·2, F. W. Clarke.*

For the oxy-cyanide, $HgCy_2HgO$, Mr. Creighton found 4·437 at 19°·2, and I myself, in two determinations, 4·428 and 4·419 at 23°·2.

For the double salt $HgCy_2HgCl_2$, Mr. Wittmann obtained the values 4·531, 21°·7, and 4·514, 26°.

For the double cyanide of mercury and potassium we have, from experiments made by Mr. Creighton, 2·4470, 21°·2; 2·4620, 21°·5; and 2·4551, 24°. This salt is the well known $2KCy . HgCy_2$.

Mercuric bromide, prepared by Mr. Miles Beamer, gave 5·7461, 18°, and 5·7298, 16°.†

* Bödeker, Jahresbericht 1860, gives for $HgCy_2$ the value 3·77, 13°.

† Karsten, Schweigg. Journ., v. 65, gives 5·9202.

The double bromide of mercury and potassium was also prepared and examined by Mr. Beamer, both in the hydrated and the anhydrous state. For the salt $HgBr_2$, KBr, he found 4·412, 17°·2; 4·419, 24°·5; 4·3996, 20°·5. For the hydrated salt, $HgBr_2 . KBr . H_2O$, as a mean of six concordant determinations taken between 20° and 24°, he found a sp. gr. of 3·867. The potassium bromide used in these preparations gave a sp. gr. of 2·712, 12°·7.*

Mr. Beamer also redetermined the specific gravity of the curious double salt $(NH_4)_2Cr_2O_7 . HgCl_2 . H_2O$, finding it to be 3·329, 21°.

Mercuric iodide and a couple of double salts were determined by Miss Mary E. Owens. For HgI_2, the mean of seven experiments between 10° and 19°, is 6·231.†

For the double iodide, $2(KI . HgI_2) . 3H_2O$, the sp. gr. is 4·289, 23°·5; and 4·254, 22°.

For the iodide of mercury and tetramethylammonium, $N(CH_3)_4I . HgI_2$, were found the values 3·968, 24°; 3·976, 23°·5; 3·971, 24°; 4·003, 23°·2. The iodide of tetramethylammonium itself, well crystallized, was found by Miss Owens to have a sp. gr. of 1·827, 17°; and 1·831, 19°·5.

Cadmium chloride and some of its double compounds were examined by Mr. Walter Knight.

The anhydrous chloride, $CdCl_2$, gave as a mean of three determinations the value 3·938, 23°.‡ The hydrated salt, $CdCl_2 . 2H_2O$, gave a sp. gr. of 3·339, 18°·2; 3·320, 23°·2; 3·314, 23°·6.

The double chloride of cadmium and strontium, $2CdCl_2 . SrCl_2 . 7H_2O$, in fine crystals; as a mean of three experiments, was found to have a sp. gr. of 2·718 at 24°.

And the barium salt, $CdCl_2 . BaCl_2 . 4H_2O$, gave the values 2·952, 24°·5; and 2·966, 25°·2.§

Several salts of acids belonging in the xanthic acid series were prepared by students under the direction of Professor R. B. Warder; and of these, three well crystallized examples had their specific gravity determined.

Potassium methyldisulphocarbonate, $K . CH_3 . COS_2$, prepared by Mr. E. P. Bishop, has a sp. gr. of 1·7002 and 1·6754 at 15°·2.

Potassium ethyldisulphocarbonate was determined by Miss Helena Stallo and by Dr. J. P. Geppert. Miss Stallo found the sp. gr. to be 1·5564, 18°·2; and 1·5576, 21°·5. Dr. Geppert's determination gave 1·558, 21°.

* Schröder's mean value for this salt is 2·690. Pogg. Ann., 1859.
† Filhol, Ann. d. Chim. et Phys. III, xxi, 1847, gives 6·250.
‡ Bödeker gives a sp. gr. of 3·6254, 12°. Jahresb., 1860.
§ Topsoë, Chem. Centralblatt, iv, 76, found 2·968.

Potassium isobutyldisulphocarbonate, also determined by Miss Stallo, has a specific gravity of 1·3718, 15°; and 1·3832, 14°·5.

A particularly interesting series of observations was made by Miss Stallo upon the formates and acetates of cobalt and nickel. I am unable to find any adequate account of these salts beyond the mere fact that they form crystalline crusts. Even the water of crystallization in them seems hitherto not to have been determined. Miss Stallo prepared these compounds by dissolving the carbonates of the metals in the respective acids, estimated the water contained in them, and determined the density. The formates of cobalt and nickel crystallize with two molecules, and the acetates with four molecules of water. The sp. grs. are as follows:

Cobalt formate,	2·1286, 22°; 2·1080, 20°·2.
Nickel "	2·1547, 20°·2.
Cobalt acetate,	1·7031, 15°·7; 1·7043, 18°·7.
Nickel "	1·7443, 15°·7; 1·7346, 17°·2.

Miss Stallo also prepared, with a view to future description, the cobalt and nickel salts of monochloracetic and trichloracetic acids. These salts are readily crystallizable, and seem likely to be interesting. Cobalt valerate, which Mr. J. L. Davis attempted to prepare, was obtained by him only as a red, gummy mass, of a very unsatisfactory character.

Another series of experiments having a certain theoretical interest, relates to some salts analogous to the sulphovinates. The data obtained are as follows:

Barium methylsulphate, $Ba(CH_3)_2(SO_4)_2 . 2H_2O$, 2·273, 19°·2; and 2·279, 21°·2, determined by Dr. Geppert.

Barium ethylsulphate, 2·080, 21°·7; 2·0714, 22°·6; Dr. Geppert.
Barium propylsulphate, 1·839, 20°·5; 1·844, 20°·5; Dr. Geppert.
Barium isobutylsulphate, 1·778, 21°·2; 1·743, 24°·2; Mr. W. H. Schuermann.
Barium amylsulphate; 1·623, 21°·2; 1·632, 22°; Mr. John Whetstone.

If now, we calculate the molecular volumes of these salts, we shall find them separated by approximately equal differences. If we assume these differences to be really equal, and distribute the experimental error among the several salts, we can get the following interesting series of theoretical values.

Methylsulphate,	molec.	vol.	176,	calc.	sp. gr.	2·244.
Ethylsulphate,	"	"	209,	"	"	2·024.
Propylsulphate,	"	"	242,	"	"	1·863.
Isobutylsulphate,	"	"	275,	"	"	1·780.
Amylsulphate,	"	"	308,	"	"	1·646.

These calculated values correspond to a supposed constant difference in the molecular volume, of 16·5 for each CH_2 group; a difference which holds in a great many series of compounds. This difference may also be made out, within narrow limits of approximation, in the series of sulphocarbonates previously given. Here, for example, we have, very nearly,

Methyl salt,	molec. vol.	88,	calc. sp. gr.	1·658.
Ethyl "	"	" 104·5,	calc. sp. gr.	1·531.
Isobutyl "	"	" 137·5,	" "	1·367.

It will be seen that all these calculated specific gravities agree closely with those actually found; and that, curiously enough, the molecular volumes thus assumed are exact multiples by whole numbers of Kopp's well known value for hydrogen, 5·5. Are these regularities mere coincidences, or do they indicate the existence of some general law?

I may give, in conclusion, a few determinations of specific gravity made by myself.

Potassium chloroplatinite, $PtCl_2.2KCl$, 3·2909, 21°; and 3·3056, 20°·3.

Telluric acid, crystallized, $H_2TeO_4.2H_2O$, 2·9999, 25°·5; and 2·9649, 26°·5.*

Telluric acid, H_2TeO_4, 3·425, 18°·8; 3·458, 19°·1; 3·440, 19°·2.

Ammonium tellurate, $(NH_4)_2TeO_4$, 3·024, 24°·5; 3·012, 25°.

Thallium tellurate. For this compound, hitherto undescribed, I can give only a few preliminary facts. By a series of mishaps my material became exhausted, so that I was unable to complete the investigation of the substances obtained. Metallic thallium is not attacked even by a boiling solution of telluric acid. When, however, a solution of ammonium tellurate is added to one of thallium nitrate, a heavy white precipitate falls, somewhat resembling silver chloride. This precipitate, dried at 100°, has a sp. gr. of 5·687, 22°; and 5·712, 20°. Heated to about 180° it turns to a pale straw-yellow color, and loses 1·46 per cent of water. The specific gravity of this yellow salt is 6·742, 16°; 6·760, 17°·5. Heated to redness, the thallium tellurate fuses, and is reduced to tellurite. This, when hot, is almost black; but solidifies on cooling, to a clear lemon-yellow glass. The exact composition of these salts remains to be determined, and I hope to return to them at some future time.

* Oppenheim, Jahresbericht, x, 213, gives 2·340.

ART. XX. — *Notice of recent additions to the Marine Fauna of the eastern coast of North America;* by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XXXVIII.

DURING the summer of 1877, extensive explorations were made by the U. S. Fish Commission in the U. S. Steamer "Speedwell," Commander Kellogg, in Massachusetts Bay; in the Gulf of Maine; off Nova Scotia; and in the vicinity of Halifax. The dredging and trawling were very successful, and a large and valuable collection was secured, both of fishes and invertebrata, including, in all classes, many European and Greenlandic forms not before obtained on the American coast. As in previous years the invertebrate collections and the direction of the dredging were in charge of the writer, who was specially assisted by Mr. E. B. Wilson, while Messrs. G. Brown Goode and T. H. Bean were in charge of the fishes. Having hitherto been unable to publish any account of these explorations, a few of the more interesting species are noticed below, together with others from different sources.

MOLLUSCA.

Architeuthis megaptera Verrill, sp. nov.

Much smaller than the previously known species, the total length of the body and head being but nineteen inches. Body relatively short and thick. Caudal fin more than twice as broad as long, the length about half that of the body. Its form is nearly rhombic, with the lateral angles produced and rounded, and the posterior angle very obtuse, the posterior edge, as preserved, being slightly concave. The ventral anterior edge of the mantle is concave centrally, with a slight angle to either side, about ·75 inch from the center; from these angles it is again concave to the sides; on the dorsal side the edge advances farther forward than beneath, terminating in a slightly prominent obtuse angle in the middle of the dorsal edge. The eye-sockets are large, oblong, and furnished with distinct lid-like margins; the eyes are large, oblong, and naked. The short arms are triquetral, the upper ones somewhat shorter and smaller than the others, which are nearly equal in length, the second pair being stouter than the rest, and a little longer. The tentacular arms are slender, elongated, expanded toward the tip, and have suckers arranged much as in the gigantic species, even to the smooth-edged suckers and opposing tubercles, proximal to the large suckers, as I have formerly described them in *A. monachus.* The sucker-bearing portion is margined by a membrane on each side.

Larger suckers of sessile arms, very oblique, with the rim strong, dark brown, bearing large, strong, sharp, much incurved, unequal teeth on the outer side of the rim; the inner margin is entire. On the middle or larger suckers of the ventral arms, there are seven large teeth, the middle one longest, while to either side there is one nearly as large, with a smaller one each side of it.

Total length, 43 inches; length of body and head, 19; length of body from dorsal edge of mantle, 14; from ventral edge, 13; of head from edge of mantle to base of arms, 5; length of long tentacular arms, 22 and 24 inches respectively; of first (dorsal) pair of arms, 6·5; of second pair, 8; of third pair, 8·5; of fourth pair, 8; length of caudal fin, 6; breadth, 13·5; breadth across body, 5; circumference of body, 12·5; length of eye-socket, 1·25; its breadth, ·75; length of sucker-bearing portion of tentacular arms, 6·5; of portion bearing large suckers, 3·25; breadth, ·75; length of terminal portion, 1·5; diameter of naked or peduncular portion, ·33 to ·50; breadth of dorsal arms at base, ·75; of second pair, 1·12; of third pair, 1; of fourth pair, 1; diameter of largest tentacular suckers, ·36 to ·40; of their rims, ·28 to ·32; diameter of largest suckers of ventral arms, ·40; of their rims, ·28 to ·32 of an inch.

Color, reddish brown speckled with darker brown, much as in the common small squids.

This unique specimen was cast ashore, during a severe gale, near Cape Sable, N. S., several years ago, and was secured for the Provincial Museum at Halifax by J. Matthew Jones, Esq. It is preserved entire, in alcohol, and is still in good condition.

Rossia Hyatti Verrill, sp. nov.

Body subcylindrical, usually broader posteriorly, in preserved specimens, variable in form according to contraction, its dorsal surface covered with small, conical, scattered, whitish papillæ, which are also found on the upper and lateral surfaces of the head and base of arms; those around the eyes largest; one on the mantle, in the median line, near the front edge, is elongated. Front border of mantle sinuous, slightly advancing in the middle, above. Fins moderately large, nearly semi-circular, attached from the posterior end for about four-fifths the whole length, the front end having a small, rounded, free lobe. The distance from posterior junction of fin to end of body is less than that from anterior junction to edge of mantle, the center of the fin being at about the middle of the body. Siphon elongated, conical, with small opening. Head depressed, more than half the length of the body. Eyes large, the lower eyelid more prominent but not much thickened. Sessile arms short, united at their bases by a short web, which is absent between the ventral arms; the dorsals are shortest; the third pair the longest and

largest; the second pair and ventrals about equal in length. Suckers numerous, subglobular, not very small; near the base of the arms they are biserial, there being usually four to six thus arranged in each row; then along the rest of the length of the arms they become more crowded and form about four rows, those in the two middle rows alternating with those in the marginal rows; toward the tip they become very small and crowded, especially on the dorsal and ventral arms. The number of suckers varies with age, but on one of the larger specimens they were as follows: on each dorsal arm, sixty; on one of second pair, fifty-five; of third pair, fifty-three; of ventral, sixty-five. In this specimen the third arm of the right side and ventral arm of left side were abruptly terminated (perhaps accidentally), while the others were tapered to acute points. Tentacular arms, in preserved specimens, will extend back to posterior end of body, the naked portion smooth, somewhat triquetral, with the outer side convex and the angles rounded; terminal portion rather abruptly widening, long ovate-lanceolate, curved and gradually tapering to the tip, the sucker-bearing portion bordered by a wide membrane on the upper and a narrow one on the lower margin; the suckers are very small, subglobular, crowded in about eight to ten rows in the widest portion.

Color, pinkish, thickly spotted with purplish brown above, paler and more sparsely spotted beneath and on outside of long arms; inner surface of arms and front edge of mantle pale.

Length from base of arms to posterior end, 40^{mm}; of body, 25; of head, 15; breadth of body, 17; of head, 17; length of fins, 15: of insertion, 11; breadth of fin, 8; front of fin to edge of mantle, 5; length of free portion of dorsal arms, 12·5; of second pair, 15; of third pair, 18; of ventrals, 13; of tentacular arms, 40; breadth of dorsal arms, at base, 3·5; of second pair, 3·5; of third pair, 4; of ventrals, 3·5; of tentacular arms, at base, 2; at expanded portion, 3·5; length of latter, 10·5; diameter of largest suckers of sessile arms, 0·9; length of free portion of siphon, 7^{mm}.

Massachusetts Bay, in fifty fathoms, mud; off Cape Sable, N. S., eighty-eight to ninety-two fathoms, on hard sandy bottom; off Halifax, fifty-seven to one hundred fathoms, on compact sandy mud, in September, with eggs. Frequently associated with *Octopus Bairdii* V., and the following species.

Rossia sublævis Verrill, sp. nov.

Larger and relatively stouter than the preceding species, with the fins larger and placed farther forward, the front edge of the large free lobe reaching nearly to the edge of the mantle. Head large and broad. Sessile arms more slender and less unequal in size than in the preceding, and with the suckers arranged in

two regular rows throughout the whole length. Anterior edge of mantle scarcely sinuous, advancing but little dorsally. Upper surface of the body and head nearly smooth, but in the larger specimens usually with a few very small whitish papillæ, most numerous near the front edge of the mantle. Color nearly as in the preceding species.

One of the largest specimens measures, from base of arms to end of body, 46^{mm}; length of body, 31; of head, 15; breadth of body, 22; of head, 23; length of fins, 20; of their insertion, 16; breadth of fins, 10; front edge of fin to edge of mantle, 2·5; length of free portion of dorsal arms, 16; of second pair, 17; of third pair, 20; of ventrals, 15; of tentacular arms, 25; breadth of dorsal arms at base, 3; of second pair, 3; of third, 3·5; of ventrals, 3·5; of tentacular arms, 3 5; of their terminal portion, 3·75; its length, 10; diameter of largest suckers of sessile arms, ·8; length of free portion of siphon, 7^{mm}.

Taken with the preceding species, and is the more common of the two, in Massachusetts Bay. The differences may prove to be only sexual, but this cannot be determined without a larger number of specimens.

Octopus granulatus Lamarck; D'Orbigny.

A specimen, believed to belong to this species, and similar to those taken at Cape Hatteras, was collected in the spring of 1877, in Vineyard Sound, Mass., by Mr. Vinal N. Edwards.

Buccinum tenue **Gray; Stimpson, Review of Northern Buccinums, Can. Naturalist, auth. copy, p. 14.**

Buccinum scalariforme **Beck; Dawson; Packard.**

Dredged alive, in considerable numbers, in 1877, off Cape Sable, N. S., in 88 to 92 fathoms, on a bottom of fine compact sand. The specimens all belong to a small form of the species. It had not been found so far south previously.

Buccinum cyaneum **Brug.; Stimpson, loc. cit., p. 19.**

Buccinum hydrophanum **Hancock; Reeve.**

The smaller form of this species was taken with the last, living, and in about equal abundance. It has hitherto been regarded as eminently arctic. We have recently received additional specimens, taken in 200 fathoms, off Sable I., by the schooner Lizzie K. Clark.

Neptunea propinqua (*Fusus propinquus* Alder).

A number of fine living specimens of this were taken with the two preceding species. They have been identified by Mr. W. H. Dall, by direct comparison with European specimens, with which they agree perfectly. This species can be distinguished at once from the far more common *N. Stimpsoni* (Mörch, sp., 1868, teste Dall = *Fusus Islandicus* Gould, and *F. curtus* Jereys) by its shorter form and hairy epidermis.

Triopa lacer Lovén.

This interesting addition to the North American fauna was dredged in 1877, at several localities, in Massachusetts Bay, in 40 to 50 fathoms; and off Nova Scotia, in 80 to 100 fathoms.

Scyllæa Edwardsii Verrill, sp. nov.

A large species, the body in extension nearly three inches long and half an inch high, with the four dorsal branchiferous lobes about equaling in height, or exceeding, the elevation of the body. Foot very narrow. Tentacular sheaths stout, expanding at the end into a large, flat, rounded lobe, most prominent posteriorly; the small, plicated tentacle projecting from a funnel-shaped orifice in its outer anterior margin. Branchiferous lobes expanding into a broad, thin, spatulate, or paddle-shaped, terminal portion, narrower and thicker toward the base, the margins of the thin portions sinuous; the two pairs far apart; their inner surfaces covered with small, translucent, whitish, arborescently branched gills, which project beyond their margins; similar gills are situated along the back in front of and behind the posterior pair of lobes, and also on the sides of the caudal lobe, which is broad, elongated, curved, upward and backward in extension, or concave in outline posteriorly, rounded at summit, and not so high as the dorsal lobes.

Color of living specimen, sent by Mr. Edwards, rich brownish yellow or orange, irregularly more or less spotted with deeper orange-brown blotches, and with opaque white specks, blotches and streaks. A band of deep yellowish brown runs along each side of the back, interrupted by the dorsal lobes, and extending up their outer edges; edges of the dorsal lobes, tentacular sheaths, and caudal lobe flake-white, which color also borders the brown band. Along each side of the body is a row of six or seven small, round, iridescent, purplish blue spots, and some smaller ones occur on the middle of the back. Anterior surface of tentacular sheath iridescent bluish. Along the sides is a row of small white papillæ, and similar ones extend along the white line of the back. Tentacles orange, the plications edged with orange-brown, the tips white.

Taken in the autumn of 1877 by Mr. Vinal N. Edwards, at Wood's Holl, Mass., on eel-grass (*Zostera*) in the harbor, and in Vineyard Sound on floating *Sargassum*. I am also indebted to Mr. Edwards for a colored drawing of this species, made by Mr. C. N. Webster, and accompanied by notes describing the appearance of the specimen when first captured. The specimen described above was not very active, though in pretty good condition, when received.

ANTHOZOA.

Keratoisis ornata Verrill, sp. nov.

Corallum tall (over two feet high), spreading, arborescently, but distantly and irregularly, branched, the branches spreading, often nearly at right angles, elongated, rather slender, gradually tapering, giving off, in the same manner, elongated branchlets. The branches and branchlets mostly arise from near the proximal end of the calcareous joints, but sometimes from the middle. The calcareous joints are ivory-white, elongated, round, slightly enlarged at the ends, faintly and often indistinctly striated longitudinally, appearing smooth to the naked eye, but finely granulous under a lens. Chitinous joints golden yellow or bronze-color, short, scarcely longer than thick in the larger branches, about twice as long as thick in the smaller ones, where they become translucent and brownish or amber-color, without the metallic luster seen in those of the larger branches. The cœnenchyma and polyp-cells are mostly absent, but so far as can be ascertained from the small patches remaining, the cœnenchyma is thin, pale yellowish, and filled with rather large fusiform spicula; and the polyp-cells are rather distant, in the form of somewhat prominent verrucæ, strengthened by rather large projecting spicula.

Height of tallest specimen, 26 inches; breadth, 18 inches; length of longest undivided branchlets, 12 to 16 inches; diameter of calcareous joints of main stem (base absent), ·35 inch (9^{mm}); of the larger branches, ·20 inch (5^{mm}); length of the calcareous joints in the larger branches, 1·25 to 1·95 inches (30 to 48^{mm}, but mostly about 40^{mm}); diameter in smaller branchlets, about ·06 inch ($1·5^{mm}$); length, ·75 to 1·25 inches (19 to 32^{mm}); length of chitinous joints of larger branches, ·10 to ·20 inch (2·5 to 5^{mm}).

Two specimens were taken by Mr. Philip Merchant, of the schooner Marion, off Sable Island, N. S., in about 250 fathoms, on a trawl line.

This is a large and beautiful species of a group formerly considered chiefly tropical in habitat. The golden or bronzy chitinous joints contrast finely with the clear ivory-white calcareous joints. The genus was founded by Professor E. Perceval Wright, in 1869, for a species taken in deep water, off the coast of Portugal.

Acanella Normani Verrill.

Mopsea arbuscula Norman, Proc. Royal Soc., p. 210, 1876 (*non* Johnson, 1862).

Two fine specimens of this elegant species were obtained by Mr. Merchant, with the preceding species. A third specimen was brought in by Mr. M. J. Murphy, from Banquereau, in the same region. The species was first described by Norman

from a specimen collected off the coast of Greenland, in 410 fathoms, by the Valorous Expedition, in 1875.

Our specimens are nearly perfect, with the cells and cœnenchyma well preserved. They are from seven to eleven inches high; and from six to ten broad. They are much branched, in the form of a dense bush or small shrub, the branches arising mostly in whorls of three or four, from the chitinous joints, and spreading nearly at right angles; the secondary branches arise in the same way, but the final branchlets mostly arise singly, or in pairs. The cœnenchyma is very thin, yellow or brown, and filled with fusiform spicula, arranged in lines; the polyp-cells are scattered, very large and prominent, with the base and distal half expanded, somewhat hour-glass shaped, largest toward the tips of the branches, and covered with large acute spicula, which project as spines beyond the margin.

The *Mopsea arbusculum* Johnson, from Madeira, is a closely allied species, for which Dr. J. E. Gray, in 1870, constituted the genus *Acanella*. It appears, from the figures, to have more slender branchlets, and polyp-cells of a different form. The coincidence in the names was, however, entirely accidental.

Fine specimens of *Primnoa reseda* and *Paragorgia arborea* are often taken in the same region from which the preceding species were obtained, as well as from the depression between St. George's and Le Have Banks, in 200 to 250 fathoms. One of the specimens of *Paragorgia* presented to us is over three feet high, and some of *Primnoa* are nearly as tall.

Paramuricea borealis Verrill, sp. nov.

Slender, arborescently much branched, four inches (or more) in height. Cells scattered, short cylindrical, or verrucose, with a series of small spicula projecting around the edge, surmounted by eight convergent groups of long, acute spicula. Cœnenchyma thin, rudely granulous, with irregular rough spicula. Color, when dried, brownish gray; axis slender, yellowish.

Grand Banks of Newfoundland, on stone, with *Primnoa reseda*. The only specimen seen was sent to me for examination by Professor A. Hyatt, from the Museum of the Boston Society of Natural History. It is near *P. placomus*, but is more slender, with longer cells.

ECHINODERMATA.

Asterina borealis Verrill, sp. nov.

Pentagonal, with a thick swollen body and short thick rays. Upper surface closely covered with short minute spinules, of nearly uniform size, arranged in groups of unequal size. Scattered over the surface are many papulæ of rather large size,

and dark purplish brown color, when contracted giving a spotted appearance to the dorsal surface. Madreporic plate small, about half way between center and margin. Margin thickened, with an upper row of slightly prominent plates spinulated like the back; below, and forming the edge, is a row of more prominent plates, their upper and inner portion spinulated like the back, the spinules increasing in length to the outer edge, where they are slender, elongated, crowded and divergent. Ventral plates, covering the triangular interbrachial area, prominent, with unequal, slender, acute, divergent spinules, those on the distal edge longest. Adambulacral plates with two internal acute spines, forming a longitudinal row, and four or five others in a transverse row on each plate. Color, in alcohol, dull yellow or buff, with dark brown spots, due to the papulæ.

Greater radius, 12^{mm}; lesser, 7^{mm}; elevation at center, 7^{mm}.

Dredged near Cashe's Ledge, Gulf of Maine, in 110 fathoms, muddy bottom, in 1874, by Dr. A. S. Packard and Mr. Richard Rathbun, on the steamer "Bache," (Coll. U. S. Fish Commission).

Lophaster furcifer Verrill.

Solaster furcifer Duben and Koren.

Taken in the Gulf of Maine, north of George's Banks, in 150 fathoms, by Dr. Packard and Mr. Caleb Cooke, on the "Bache," in 1872. This species differs so widely from *Solaster* in the structure of the skeleton, and the small development of the disk, as to require the establishment of a new genus for this type. It is specially distinguished by the highly developed skeleton of the under side; differentiated marginal plates; and prominently reticulated dorsal plates.

Pedicellaster typicus Sars.

This species was dredged in the Gulf of St. Lawrence, in 1872, by Mr. J. F. Whiteaves, who sent me specimens for examination.

Asterias stellionura Perrier.

This large and remarkable species, previously known only from Iceland and Greenland, was dredged by our party, on the steamer Speedwell, in 1877, at several localities off Nova Scotia, in large numbers. It was especially abundant off Cape Sable, in eighty-eight to ninety-two fathoms, fine compact sand; and off Halifax in one hundred fathoms, sandy mud, where it was associated with *Astrogonium granulare*, *Hippasteria phrygiana*, *Archaster Parelii*, *Archaster arcticus*, *Antedon Sarsii*, and many other arctic species.

This species can be distinguished from all others of our coast by the five, very long, angular arms, with long slender spines, which are surrounded at base by large dense wreaths of crossed

pedicellariæ. In life these clusters of pedicellariæ are supported on soft extensible processes, which project beyond the ends of the spines of the lower surface, giving it a very peculiar appearance. Some of the specimens were two feet in diameter. The color was usually bright red above, yellowish below; some specimens varied to orange-red, and others to purplish or brownish red, above.

Ophiacantha anomala G. O. Sars, Vidensk.-Selsk. Forhandl., 1871.

A handsome species, having six arms, and of a bright salmon-color when living. A single specimen was dredged by us in the Gulf of Maine, 140 miles east of Cape Ann, in 112 fathoms, sand and gravel, in 1877.

With this was associated another beautiful salmon-colored species (*?Amphiura Otteri* Ljung.) with five long slender arms. *Ophioscolex glacialis* also occurred at the same locality. Both the latter had, however, been taken by our parties in previous years.

ART. XXI.—*Positions of the Comet discovered by Mr. Lewis Swift;* by C. H. F. PETERS. (From a letter to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., July 6, 1878.)

OF the comet found by Mr. Lewis Swift of Rochester on July 6, the following positions were here obtained:

1878.	Ham. Coll. m.t.	α Comet.	δ Comet.	
	h. m. s.	h. m. s.		
July 7,	12 33 43	17 34 19·87	+16° 57′ 31·5″	6 comp.
July 10,	13 5 53	17 17 10·24	+ 9 39 32·2	10 "
July 19,	10 27 58	16 30 35·35	—12 42 22·5	4 "
July 23,	9 42 12	16 12 41·58	—21 18 16·9	8 "

The approximate parabolic elements herefrom derived are:

(Epoch) Time of Perihelion passage, July 20·753 Berlin m. t.

$$\left.\begin{aligned} \pi &= 279^\circ 52'{\cdot}06 \\ \Omega &= 102\ \ 15{\cdot}72 \\ i &= 78\ \ 11{\cdot}41 \end{aligned}\right\}\text{M. Eq. 1878·0.}$$

$\log q = 0{\cdot}14360.$

Motion : direct.

Much labor would be saved to astronomers, if comet-hunters like Mr. Swift, would indicate the position of a new discovery with a little more accuracy. For obtaining it with only a few minutes' error, nothing else is needed but a common watch in connection with the field of the telescope used as a ring-micrometer.

ART. XXII.—*The Waverly Group in Central Ohio;* by L. E. HICKS, Professor of Natural Sciences in Denison University.

IN this paper I propose to enumerate and describe the strata lying between the Huron Shales (Devonian) and the base of the Coal Measures, and to consider briefly their stratigraphical relations. I shall use names derived from localities in Licking and Delaware Counties—not that I wish to add to the already profuse nomenclature of this group, but as a matter of necessity until the application of the names proposed by other geologists has been definitely settled. The section contains five well defined members, named below in descending order.

5. Licking Shales	100 to 150 feet thick.
4. Black Hand Conglomerate and Granville Beds	85 " 90 "
3. Raccoon Shales	300 "
2. Sunbury Black Slate	10 " 15 "
1. Sunbury Calciferous Sandrock	90 " 100 "

The Licking Shales, No. 5, are well developed in the hills bordering Licking River from Newark to Black Hand. They lie seventy to eighty feet above the water level, forming the middle of the slope of these hills, the base being composed of the massive Black Hand Conglomerate and the upper slopes and summit of the various strata of the Coal Measures, of which the Coal Conglomerate and Massillon Sandstone produce the most conspicuous effects in the landscape. At or near the top of No. 5 there is usually a stratum of compact, fine-grained, drab sandstone, which is quarried to some extent, having a thickness of three to ten feet. Below this are friable, earthy, gray or olive shales; and at the bottom, comprising about one-third of the whole, shaly drab sandstones. These, and the compact sandstone at the top, are fossiliferous. *Spirifera Carteri*, *Aviculopecten Winchelli*, *Allorisma pleuropistha*, and other characteristic species of the Ohio Subcarboniferous, have been obtained from this horizon.

Wherever the Coal Measures Conglomerate exists it forms the upper limit of the Licking shales, which is then well defined. In the absence of the Conglomerate the only means of determining its extent upward is the position of the compact sandstone and the presence of Subcarboniferous fossils. Frequently the sandstone is overlaid by shales differing scarcely at all from those below it. The lower limit, however, is perfectly defined by the upper surface of the next stratum, which is one of the most distinctive and well-marked of the whole group.

The Black Hand Conglomerate, No. 4, is seen at its best about Hanover, though the Black Hand locality is better known, probably because the cliffs at that point are more conspicuous to the railway passenger. Only about half its thickness is seen in these cliffs. At Hanover the bottom layers (which, owing to the eastward dip, are buried out of sight at Black Hand) come into view and reveal a total thickness of eighty-five to ninety feet. It is generally a rather fine pudding-stone, the pebbles of the size of peas. Occasionally they are an inch in diameter, and, in one case, I found a quartzite bowlder six inches long and three inches thick imbedded in the sandy matrix. In some places beds many feet thick are merely coarse sandstone, but the partings are pebbly. The prevailing color is light yellow or buff; sometimes nearly white, again brick-red. This stratum is highly ferruginous, but less so than the Coal Conglomerate, the upper layers of which are sometimes a siliceous iron ore. It also contains more earthy matter and less pure silica than the Coal Conglomerate. These characters, together with the presence of fossil nuts (*Cardiocarpon*, *Trigonocarpon*, etc.) in the upper, and their absence, so far as yet observed, in the lower, might serve to distinguish these conglomerates if they were in contact, instead of being separated by the Licking Shales.

No. 4 is evidently a shore deposit, and it exhibits the typical structure of a sea-beach better than any other rock with which I am familiar. There is, in the first place, the regular beach slope of four to ten degrees, which for six miles along the Licking River is tolerably constant in direction, viz: N. 10° to 45° E. Then there are subordinate lines of oblique lamination dipping in all directions. These last do not, however, interfere with quarrying. The rock splits along the beach slope as if that was the dip, and comes out in regular blocks of any size desired. In durability it is unsurpassed, while it is not destitute of beauty as a building stone. Its great value for canal locks, bridge abutments, foundations, etc., has long been recognized; and its capabilities for massive and elegant superstructures have been shown in the erection of the cathedral at Columbus.

Like almost all Conglomerates, No. 4 thins and disappears, or passes into fine sediments when traced far from its typical exposures. Black Hand is near the east line of Licking County. The Conglomerate appears in full force for seven or eight miles, to some distance west of Clay Lick station on the Baltimore and Ohio Railroad. Thence through the center of the county its horizon is occupied by an entirely different set of beds, of which only one, and that thin, bears any resemblance to the rock at Black Hand. These beds are character-

istic and important enough to merit a full description and a separate name. They are well exposed at Granville, and we may for convenience designate them as the Granville beds, remembering that they are only a local modification of No. 4, or the next highest member of the Waverly group. Following is the section of these beds in descending order:

No. 4*d*.	Coarse sandstone and conglomerate....	3 to 18	feet.
" 4*c*.	Fucoid layer	7 " 12	"
" 4*b*.	Compact drab sandstone (argillaceous).	15 " 21	"
" 4*a*.	Shaly " " and shales ...	60	"

The upper member, No. 4*d*, thickens and grows coarse and pebbly eastward, and tapers to a knife-edge westward. Hence I was at first disposed to regard it alone as the equivalent of the Black Hand conglomerate, and to suppose that the rest of the Granville beds dipped under that stratum. But careful measurements have shown that the bottom of the Granville beds near Newark is nearly the same distance below Coal I. as the bottom of the conglomerate at Black Hand; so that, if the latter is superimposed upon the former, there must be a sudden thickening of the whole series to the extent of eighty or ninety feet. The general regularity of the dip renders this highly improbable.

The Fucoid layer, No. 4*c*, is composed of brown, gray, and blue, earthy shales, filled with the remains of *Spirophyton cauda galli*. At some points these plants are so numerous that the whole rock becomes a tangled mass of sea-weeds. It weathers black by the oxidation of its manganese. The upper half is more friable than the lower, and falls to pieces in being removed; the workmen in some quarries call it "soapstone." The lower half, "nigger-head," requires blasting, being quite compact in the quarry, from which it has to be "stripped" to get at the next layer, No. 4*b*; but it soon falls to pieces under the action of the elements and lays bare the rich treasures of its molluscan fauna, which the quarrymen call "bugs" and "butterflies."

This layer is so well defined and persistent that it furnishes a reliable means of determining the dip. This has been found to be on the average twenty-one feet ten inches per mile, nearly due east. Instead of being uniform, however, this general eastward slope is broken into small waves, which correspond to the greater ones in the Appalachian mountain system, both in direction and in having their western slope steeper than the eastern.

No. 4*b* is a fine-grained, easily-wrought sandstone, extensively quarried at Newark and Granville. The shaly sandstone below it also thickens in some places into layers suitable for quarrying, but it is not reliable.

All the Granville beds are fossiliferous. They have, in fact, yielded a richer harvest to the paleontologist than any other member of the Waverly. Not less than seventy-five species, many of them new to science, have been found in them in a tolerable state of preservation; and several more have been seen, but only in fragments too imperfect for identification or description. In the upper layer, No. 4*d*, the remains of mollusks and crinoids have supplied enough calcareous matter to convert portions of the rock into an impure limestone. The carbonate of lime dissolves out on exposure to the weather, leaving a rusty, rotten sandstone full of fossils, but seldom furnishing a perfect or entire specimen. In the compact sandstone the fossils are fairly preserved, but generally as "casts." From the Fucoid layer, however, beautifully perfect shells are obtained with both valves entire and in position, the matrix crumbling away on exposure.

The unity of the Granville beds with the Black Hand conglomerate, constituting under local modifications a single member of the series, appears not only in that they occupy the same stratigraphical horizon, but that there is unity and harmony in their topographical effects. Both combine to produce the picturesque hilly region extending through the central and eastern part of Licking County. These effects are intensified at Hanover and Black Hand by the Coal Conglomerate, or, in its absence, the Massillon sandstone, in the upper slopes and summits of the hills, whose rugged aspect is further heightened by mural cliffs and by the presence of hemlock, laurel and other species which usually affect a mountainous habitat. West of Granville the hilly region terminates somewhat abruptly, only a few comparatively gentle swells beyond rising and sinking into the general level of the flat, monotonous country underlaid by the Raccoon shales.

This stratum, No. 3, appears in force all along Raccoon Creek and its tributaries, and extends westward into Franklin and Delaware Counties. An estimate based upon the breadth of its outcrop and the dip, as ascertained from the Fucoid layer, makes its thickness three hundred feet. It is composed of blue and gray shales full of concretionary masses of iron ore, which are, however, mere shells filled with marl or sand. Near the bottom some layers are massive enough for quarrying. No animal remains have been observed in it; but there are abundant impressions of two species of sea-weeds, one with square stem branching at right angles, the other with round stem branching in the usual manner.

The next stratum, No. 2, as much exceeds the last in interest as it falls short of it in thickness. It is a black, bituminous shale containing shells of *Lingula* and *Discina*, and spines,

scales and teeth of fishes. But one outcrop of it is known in Delaware County, and that was revealed only by a systematic search of a day and a half. This discovery, which I made in May, is recorded in the July number of this Journal. An equally diligent search would, I am confident, result in tracing the same stratum much farther north; and thus the identity of one at least of the Waverly beds in southern, central and northern Ohio, would be established beyond a peradventure.

The last member, No. 1, consists of shaly sandstone, compact sandstone (somewhat calcareous) and at the bottom a few feet of alternate shales and siliceous limestones. The calcareous matter is abundant enough to charge the water percolating through the rock and form extensive deposits of travertine on the banks of Rattlesnake and Walnut Creeks. The forest trees drop their leaves upon the surface of this travertine; they are caught in the petrifying mass and leave their models exact to the minutest detail. I have collected many beautiful specimens of oak, chestnut, maple and beech leaves from this locality.

The rock which furnishes the material for the travertine is itself non-fossiliferous, at least as regards the remains of animals. It contains two species of sea-weeds distinguished by their position in the stone, one standing vertical, the other lying flat. The Portage sandstone of New York has two species which are distinguished in the same way. They belong, however, to different horizons, the vertical one being found in the upper beds only, and thus furnishing a basis of subdivision. In the Waverly no difference in their vertical distribution has been observed.

The quarries in the lower Waverly at Sunbury, Delaware County, furnish an excellent quality and inexhaustible quantity of flagging and building stone. Ripple marks are so abundant that thousands of feet of flagging have been sold, every slab of which would be a good cabinet specimen.

Near the junction of No. 1 with the Huron shale is a stratum of Calciferous sandrock lying in huge, rough, concretionary masses. Below this are blue shales interstratified with thin layers of siliceous limestone, the lowest of which rests directly upon the surface of the Huron. Here we reach an unmistakable Devonian stratum, and our task of enumerating and describing the component members of the Waverly group is completed.

It remains to discuss the stratigraphical relations and names of the beds described above, which is by no means the easiest part of my undertaking.

Let us first inquire what is the relation of the several members constituting the Waverly in central Ohio to those in Dr. Newberry's section at Cleveland, which is as follows:

The Conglomerate.

1. Cuyahoga Shale,	150 to 250 feet thick,		Waverly Group.
2. Berea Grit,	60	"	
3. Bedford Shale,	75	"	
4. Cleveland Shale,	21 to 60	"	
Erie Shale (Chemung),			

The Cleveland Shale has been assumed by the Ohio geologists to be equivalent to the Waverly Black Slate, which is undoubtedly the same as that at Sunbury (Newberry, Ohio Reports, vol. ii, p. 93. Orton, ibid., p. 624). At the time I discovered the outcrop at Sunbury I supposed there was no doubt of the correctness of this assumption. Now, however, Dr. Newberry asserts positively that there is *no evidence* that they are identical. Until further explorations are made north of Delaware County, we shall therefore have to be content with hypothetical statements respecting the relation of Waverly beds in central and northern Ohio. For instance, if the Sunbury black slate is identical with the Cleveland shale, then the Sunbury Calciferous sandrock is equivalent to the Erie shale, and the three upper members in Licking County are collectively equivalent to Bedford, Berea and Cuyahoga, though it would not be safe to assert distributively that Bedford=Raccoon, Berea=Black Hand and Cuyahoga=Licking. Again, if Professor N. H. Winchell was correct in pronouncing the Sunbury quarry stone Berea grit, then the Cuyahoga shales alone represent all the four upper members in central Ohio, and the Chocolate shale described by President Orton as constituting the upper part of the Huron may be of the same age as the Bedford shales, as they were supposed to be by Dr. Newberry. But such conditional statements are hardly worth the utterance. In the present state of our knowledge the problem of exactly synchronizing any of the subdivisions of the Waverly seems to be insoluble.

A more important problem is that which pertains to the general synchronism of the whole group: Is it Carboniferous? or Devonian? or partly one and partly the other?

It is no new thing for the intervening strata between two great formations to be the subject of much discussion before their true relations are settled; or, if not settled, at least *let alone*, the advocates of opposite theories either dying off or tacitly agreeing to disagree. If the question proves incapable of solution there are several ways of *dodging* it. One mode of doing this is to call the disputed strata "beds of passage." This is not, however, eminently satisfying and calming to a logical mind. The same may be said of that other expedient of enumerating the members acknowledged to belong to each formation, and then placing the bone of contention in an ambiguous position half way between, as is often done with the Oriskany

sandstone. Still another plan is to compound the names of the underlying and overlying formations, and apply the compound to the disputed rocks, as in the case of the Cambro-Silurian of Great Britain, a term which recalls the long and hot Sedgwick-Murchison controversy. After all, though, these expedients are in some measure philosophical and reasonable, though not strictly logical. Logic is in fact more rigid than nature. She demands clean-cut divisions, hard-and-fast lines of separation, in the classificatory sciences. But it is a melancholy fact for logic-choppers that nature is *not* rigidly logical. Whether in geology, biology, or what you will, the facts and objects of nature refuse to yield to the systematist group which are, in all cases, sharply defined. Thus room is always left for differences of opinion in regard to the propriety of this or that being classed here or there. All we ought to demand, therefore, of the systematist, is that he shall not run counter to the plain and emphatic deliverances of nature herself; and where the evidences are nicely balanced we may well concede to him some degree of arbitrary power in the construction of his groups. The convenience of having *some* classification may make it expedient to accept his work, though, at certain points, logical considerations have driven him to draw sharper lines than exist in nature. If we approach this problem bearing these considerations in mind, we shall be more likely to view it broadly and judicially.

The Waverly was long regarded as Devonian. When the present Geological Survey of Ohio was organized, one of the first announcements made by its chief, Dr. Newberry, was that the Waverly was Carboniferous. This decision covered only what we may conveniently call the Cuyahoga sub-group, i. e., Cuyahoga shales, Berea grit, Bedford shales, and Cleveland shales. That part of the Waverly which is probably equivalent to the Erie shales would still fall to the Devonian if Erie is Devonian; and that was tacitly admitted by the chief geologist, though he now claims that he placed it there out of deference to the prevalent classification, all the while believing that the true boundary of the Carboniferous was at the base of the Erie in Ohio and of the Portage sandstone in New York. His statements in the first volume of the Ohio Reports, p. 166, and vol. ii, p. 82, justify this claim and exonerate him from the charge of reversing his own decision in affirming, as he now does, that the whole of the Waverly, the Erie, the Portage, the Chemung and the Catskill are Carboniferous.

While it may be true that this is no real change, though it is an apparent one, in Dr. Newberry's opinions, it is certainly a great and radical change in the classification of American rocks, and the reasons for it merit our closest scrutiny. These alleged

reasons are: 1st. A physical break at the close of the Hamilton, the previous movement of elevation being then reversed and a new cycle of deposition begun which culminated in the deposition of the Subcarboniferous Limestone. 2d. "A change of fauna; the fossils of the Chemung and Upper Portage, that is Erie, show great development of the Productus family, and other fossils of Carboniferous type."*

A physical break of some magnitude and a marked change of fauna are certainly the two things, and the only two, upon which to base the boundaries of formations. But the break here appealed to is only one of a number of such changes, and of no greater magnitude than some others in the same series. For instance, at the close of the Chemung a large area in central and western New York was raised above the sea-level, not again to be submerged, thus checking and reversing the subsidence which began with the Portage. Dana states the nature of the transition from the closing period of the Devonian to the opening of the Carboniferous as follows: "The former was a period in which the grand Appalachian subsidence (as in other parts of the Devonian) reached north into the State of New York, while in the latter it hardly passed the limits of Pennsylvania. The former was characterized by dry land, over a large portion of the great Interior Continental basin; the latter, by a wide-spread and clear, though not deep, sea, growing Crinoids and forming limestones." (Manual of Geology, p. 281.) In this passage a contrast of physical conditions is indicated which is certainly equal, if not superior in importance, to the physical break at the close of the Hamilton period.

As regards the change of fauna it was not general enough to be of commanding importance. The Carboniferous aspect of Chemung fossils is confined to those from western New York and Pennsylvania. Those from the eastern part of both these States are strongly Devonian in their prevailing types. Still higher than the Chemung is the Old Red Sandstone containing both a fauna and flora which have respectable claims to be regarded as Devonian.

I freely admit that there is no hard-and-fast line of separation between the Carboniferous and Devonian. Fix the boundary where you will, there will be room for caviling and dissent. The English geologists have even proposed to wipe out the Devonian as an independent formation, giving its components to the Carboniferous and Silurian. It is to be hoped *that* will never be done, for it would open the door to endless controversies respecting the new boundary. When we remember that all classification must be somewhat arbitrary; that the logical rhythm of any system often demands the *accentuation* of

* From a letter to the writer.

certain distinctions, so that their apparent value in the scheme exceeds their absolute value in nature; that names and groups are, in some degree, matters of usage, of comity, and of convenience, we may well pause before we precipitate the inconveniences of unsettling a long established and generally received classification, especially if our substitute only accentuates another set of distinctions of no greater absolute value than the former. Unless there is a decided preponderance of evidence in favor of the new, the old is entitled to prevail by right of priority and possession.

Professor Lesley's identification of the Bedford shale with the Old Red Sandstone, and Cleveland shale with Oil Sands and Chemung, thus dividing the Cuyahoga group in the middle and giving its two lower members to the Devonian, seems to me to lack sufficient grounds to justify it. In his note on the "Comparative Geology of Northern Ohio, Northwestern Pennsylvania, and Western New York" (2d Geological Survey of Pa., 1874, i,) where this opinion is announced, no distinct line of argument in its behalf is indicated. The local red color of the Bedford is of such small significance that I cannot believe *that* had any weight in the mind of so experienced a geologist. The Cuyahoga, Berea, Bedford and Cleveland, including the few feet of limestone under the latter, constitute a compact and natural group, holding substantially the same fauna throughout. I hope to show this more in detail in a subsequent paper on the vertical distribution of the fossils of this group. Then again, the fossils of the Cleveland shale, at the bottom of the series, are of decidedly Carboniferous types. These facts constitute a sufficient reason for retaining the Cuyahoga sub-group in the Carboniferous, whatever may be done with the rest of the Waverly.

ART. XXIII.—*On some Primordial Fossils from Southeastern Newfoundland;* by J. F. WHITEAVES, Paleontologist to the Geological Survey of Canada.

DURING the summer of 1874, Mr. T. C. Weston, of the Canadian Geological corps, spent a few days in collecting Primordial fossils from the shores and neighborhood of St. Mary's, Trinity and Conception Bays, Newfoundland, on behalf of Mr. A. Murray, Director of the Geological Survey of that Island. Most of the specimens obtained have been described and figured by Mr. Billings in the first part of the second volume of his "Palæozoic Fossils" of Canada, but a few remain of which no account has yet been published and which appear to be of sufficient interest to deserve a short notice.

The majority are from the banks of Manuel's Brook, a small stream which is not indicated in most maps of the island, but which runs into Conception Bay, on its eastern side, not far from Topsail Head. In Mr. Murray's Report of the Geological Survey of Newfoundland for 1868, the following paragraphs occur. "On Manuel's Brook a very coarse conglomerate may be seen, in strong and moderately regular beds, resting directly upon the syenitic gneiss of the valley above, dipping to the north at an angle of 15°, and forming a picturesque fall about one hundred and fifty yards below the bridge on the Bay Road." (p. 23.) "About four hundred yards below the bridge the conglomerate is overlaid conformably by a set of dark brown or blackish shales, with a very fine lamination coinciding with the bedding, which, with some hard calcareous beds interstratified, hold the banks of the brook until within a short distance of its exit into the Bay." (p. 24.) In the same report the thickness of these conglomerates is estimated at fifty feet and that of the shales at two hundred and fifty. (p. 27.) Sir W. E. Logan, in 1866, expressed the opinion that the slates of St. John, Newfoundland, probably belong to the same horizon as the Acadian or St. John's Group of St. John, N. B., and although little or no paleontological evidence of a satisfactory character had been obtained on the point, it has been supposed by Mr. Murray and others, that the shales of Manuel's River are of similar age. The correctness of the latter view is however fully borne out by the fossils collected by Mr. Weston, which are as follows.

1. *Agnostus Acadicus* Hartt. Not unfrequent, but usually a little larger than the types from St. John, N. B.

2. *Agnostus* (sp. undt.). A single head, apparently distinct from the preceding and perhaps new.

3. *Microdiscus punctatus* Salter. Abundant. This interesting species, which was originally described from the Lower Lingula Flags of South Wales, and which Mr. Salter thought might be "the fry of some larger trilobite," was first detected in the Primordial slates of St. John, N. B., by the late Mr. E. Billings. It has since been observed in rocks of the same age on the Kennebecasis River, N. B., where it was collected by Mr. G. F. Matthew. *M. punctatus* is said to have an "enormous nuchal spine," but, judging by Mr. Salter's figures, there is no spinous process on either of the postero-lateral angles of the head; the number of rings on the axis of the tail also is stated to be seven.

4. *Microdiscus Dawsoni* Hartt. One perfect and well preserved head. Very similar in sculpture to the preceding. The two forms occur together in the same pieces of rock from Newfoundland and New Brunswick and are very likely only different states of preservation of the same species. According to

Mr. Hartt the posterior angles of the cephalic shield of *M. Dawsoni* bear "backward projecting spines," the glabella is described as "conical and pointed behind" but not spinous, and the middle lobe or axis of the tail as divided into six segments. The figure of the head of this trilobite, in the "Acadian Geology," is defective and does not show the lateral spines.

5. *Conocephalites tener* Hartt. Two heads of this easily recognized and well characterized form.

6. *Conocephalites Baileyi* Hartt. A single head, with an unusually small glabella.

7. *Conocephalites Orestes?* Hartt. Abundant, but badly preserved and hence the doubt as to the correct identification of the species. The facial sutures of Nos. 5, 6 and 7 being unknown their generic position is of course uncertain.

8. *Paradoxides* (sp. undt.). Fragments only.

Nos. 1, 3, 4, 5, 6 and possibly 7 are common to the Primordial slates of St. John, N. B., and to the shales of Manuel's Brook.

The shales of Kelly's Island, in Conception Bay, hold quantities of a small *Lingula* which appears to be undescribed and which may be briefly characterized thus:

Lingula Billingsiana, n. sp. Shell small, very slightly convex, compressed at the sides: outline elliptic ovate, narrowest behind: length nearly twice the width: margin of the valves widening convexly and gradually from the beaks to the center, or a little beyond it: front narrowly and evenly rounded. Surface marked by fine concentric striations and faint radiating lines. Internal markings unknown. Length, about two lines and a half: width one line and a half.

This little shell, which may be the young of some larger species, is somewhat similar in shape and size to the *Lingula minima* of Sowerby, from the Upper Ludlow rocks of Great Britain. The two shells, however, belong to very different geological horizons, and besides this, *L. Billingsiana* is much narrower posteriorly than *L. minima* and not nearly so square in front.

From Mr. Murray's report already quoted it would appear that the shales of Kelly's Island are not quite so old as those of Manuel's Brook, but that they are older than the Menevian sandstones of Great Bell Island.

ART. XXIV.—*The Solar Eclipse of July 29th*, 1878; by Professor HENRY DRAPER, M.D.

As I have recently been giving attention to the subject of solar spectroscopy in consequence of my discovery of oxygen in the sun, it seemed to be desirable to take advantage of the total eclipse of July 29th, to gain as precise an idea as possible of the nature of the corona, because the study of that envelope has been regarded as impossible at other times. The main point to ascertain was whether the corona was an incandescent gas shining by its own light, or whether it shone by reflected sunlight.

For this purpose I organized an expedition, and was fortunate enough to secure the coöperation of my friends Professors Barker and Morton and Mr. Edison. The scheme of operations was as follows: 1st, the photographic and photo-spectroscopic work as well as the eye slitless spectroscope were to be in charge of my wife and myself; 2d, the analyzing slit spectroscope was in charge of Professor Barker, with the especial object of ascertaining the presence of bright lines or else of dark Fraunhofer lines in the corona; 3d, the polariscopic examinations were confided to Professor Morton, who was also to spend a few moments in looking for bright or dark lines with a hand spectroscope; 4th, Mr. Edison carried with him one of his newly invented tasimeters with the batteries, resistance coils, Thomson's galvanometer, etc., required to determine whether the heat of the corona could be measured.

This entire programme was successfully carried out and good fortune attended us in every particular. The results obtained were: 1st, the spectrum of the corona was photographed and shown to be of the same character as that of the sun and not due to a special incandescent gas; 2d, a fine photograph of the corona was obtained, extending, in some parts, to a height of more than twenty minutes of arc, that is, more than 500,000 miles; 3d, the Fraunhofer dark lines were observed by both Professors Barker and Morton in the corona; 4th, the polarization was shown by Professor Morton to be such as would answer to reflected solar light; 5th, Mr. Edison found that the heat of the corona was sufficient to send the index beam of light entirely off the scale of the galvanometer. Some negative results were also reached, the principal one being that the 1474K, or so-called corona line, was either very faint or else not present at all in the upper part of the corona, because it could not be observed with a slitless spectroscope and the slit spectroscope only showed it close to the sun.

The general conclusion that follows from these results, is, that on this occasion we have ascertained the true nature of the

corona, viz: it shines by light reflected from the sun by a cloud of meteors surrounding that luminary, and that on former occasions it has been infiltrated with materials thrown up from the chromosphere, notably with the 1474 matter and hydrogen. As the chromosphere is now quiescent this infiltration has taken place to a scarcely perceptible degree recently. This explanation of the nature of the corona reconciles itself so well with many facts that have been difficult to explain, such as the low pressure at the surface of the sun, that it gains thereby additional strength.

The station occupied by my temporary observatory was Rawlins (latitude 41° 48′ 50″, longitude 2^h 0^m 44^s W. of Washington, height 6732 feet above the sea) on the line of the Union Pacific railroad, because, while it was near the central line of totality, it had also the advantages of being supplied with water from the granite of Cherokee Mountain and of having a repair shop where mechanical work could be done. I knew by former experience that the air there was dry and apt to be cloudless; in this particular our anticipations were more than fulfilled by the event, for the day of totality was almost without a cloud and the dew-point was more than 34° F. below the temperature.

The instruments we took with us were as follows and weighed altogether almost a ton. 1st. An equatorial mounting with spring governor driving clock, loaned by Professor Pickering, Director of Harvard Observatory. 2d. A telescope of five and a quarter inches aperture and seventy-eight inches focal length, furnished with a lens specially corrected for photography, by Alvan Clark & Sons. 3d. A quadruple achromatic objective of six inches aperture and twenty-one inches focal length, loaned by Messrs. E. and H. T. Anthony, of New York; to this lens was attached a Rutherfurd diffraction grating nearly two inches square, ruled on speculum metal. The arrangement, with its plate holders, etc., will be designated as a photo-telespectroscope. 4th. A four-inch achromatic telescope with Merz direct vision spectroscope, brought by Professor Barker, from the collection of the University of Pennsylvania. 5th. A four-inch achromatic telescope, also brought by Professor Barker; to it was attached Edison's tasimeter. Besides these there were polariscopes, a grating spectroscope, an eye slitless spectroscope with two-inch telescope, and, finally, a full set of chemicals for Anthony's lightning collodion process, which in my experience is fully three times quicker than any other process.

The arrangement of the photo-telespectroscope requires farther description, for success in the work it was intended to do, viz., photographing the diffraction spectrum of the corona, was difficult and in the opinion of many of my friends impossible.

In order to have every chance of success it is necessary to procure a lens of large aperture and the shortest attainable focal length, and to have a grating of the largest size adjusted in such a way as to utilize the beam of light to the best advantage. Moreover, the apparatus must be mounted equatorially and driven by clockwork so that the exposure may last the whole time of totality and the photographic work must be done by the most sensitive wet process. After some experiments during the summer of 1877 and the spring of 1878, the following form was adopted.

The lens being of six inches aperture and twenty-one inches focal length, gave an image of the sun less than one-quarter of an inch in diameter and of extreme brilliancy. Before the beam of light from the lens reached a focus it was intercepted by the Rutherfurd grating set at an angle of sixty degrees. This threw the beam on one side and produced there three images—a central one of the Sun and on either side of it a spectrum; these were received on three separate sensitive plates. One of these spectra was dispersed twice as much as the other, that is, gave a photograph twice as long. This last photograph was actually about two inches long in the actinic region. If, now, the light of the corona was from incandescent gas giving bright lines which lay in the actinic region of the spectrum I should have procured ring-shaped images, one ring for each bright line. On the other hand, if the light of the corona arose from incandescent solid or liquid bodies or was reflected light from the Sun I was certain to obtain a long band in my photograph answering to the actinic region of the spectrum. If the light was partly from gas and partly from reflected sunlight a result partly of rings and partly a band would have appeared.

Immediately after the totality was over and on developing the photographs, I found that the spectrum photographs were continuous bands without the least trace of a ring. I was not surprised at this result because during the totality I had the opportunity of studying the corona through a telescope arranged in substantially the same way as the photo-telespectroscope and saw no sign of a ring.

The plain photograph of the corona taken with my large equatorial on this occasion shows that the corona is not arranged centrally with regard to the sun. The great mass of the matter lies in the plane of the ecliptic but not equally distributed. To the eye it extended about a degree and a half from the sun toward the west while it was scarcely a degree in length toward the east. The mass of meteors, if such be the construction of the corona, is therefore probably arranged in an elliptical form round the sun.

For the fortunate results of this expedition we are not a little indebted to the railroad and express companies. The Pennsylvania, the Chicago and Northwestern and the Union Pacific railroads, the Pullman Palace Car Company, and the American and Union Pacific Express Companies made the most liberal arrangements, and Mr. Galbraith, the Superintendent of the Repair Works at Rawlins, gave us the free use of his private house and grounds. Of the citizens of Rawlins it is only necessary to say that we never even put the lock on the door of the Observatory, and not a thing was disturbed or misplaced during our ten days of residence, though we had many visitors. They sent us away with a serenade.

ART. XXV.—*Discovery of an Intra-Mercurial Planet;* by JAMES C. WATSON.

AT the recent total eclipse of the sun I was occupied exclusively in a search for any intra-Mercurial planet which might be visible. For this purpose I employed an excellent four-inch refractor, by Alvan Clark & Sons, mounted equatorially, with a magnifying power of forty-five. There were no circles originally attached to the instrument and, accordingly, I placed on it circles of hard wood, the declination circle being five inches and the hour circle four and three-quarter inches in diameter. On these I pasted circles of card-board, and pointers were provided so that I could mark with a sharp pencil the position corresponding to any particular pointing of the instrument. This method does not compare in accuracy with graduated circles and verniers, but it has the advantage, and a very important one in the present case, of avoiding the uncertainty which might be attributed to erroneous readings of the circles. To read the divided circles would require considerable time, while the pointings can be marked on the paper discs in a few moments. And besides, while a doubt might be raised as to the correctness of the recorded circle readings, no such doubt can exist in reference to the positions marked on these paper circles. The chronometer times corresponding to each pointing were recorded, and the designation of the object observed was also marked on the paper discs, so that there is no difficulty in identifying the several marks.

Before the commencement of the eclipse, the inclination of the polar axis of the instrument was adjusted and it was brought into the meridian as nearly as possible. The error therefore arising from the imperfect adjustment of the equatorial mounting will be small. A few minutes before the totality

of the eclipse I swept over the regions east and west of the sun, from eight degrees to fifteen degrees distant, but no stars were seen. Immediately after the commencement of totality I began sweeps east and west extending about eight degrees from the sun. I had previously committed to memory the relative places of stars near the sun down to the seventh magnitude, and the chart of the region was placed conveniently in front of me for ready reference whenever required. The first sweep began with the sun in the middle of the field, and extended eastward about eight degrees and back, and I saw δ Cancri and smaller stars marked on the chart. The next sweep was one field farther south, and eastward and back as before. Then placing the sun in the field I commenced a corresponding sweep to the westward. Between the sun and θ Cancri and south of the middle of the field, I came across a star, estimated at the time to be of the four and a half magnitude, which shone with a ruddy light and certainly had a larger disc than the spurious disc of a star. The focus of the eye-piece had been carefully adjusted beforehand and securely clamped, and the definition was excellent. I proceeded, therefore, to mark its position on the paper circles, and to record the time of observation. It was designated by *a*. The place of the sun had been recorded a few minutes previously and marked S_1. Placing my eye again at the telescope I assured myself that it had not been disturbed, and proceeded with the search. I noticed particularly that the object in question did not present any elongation such as would be probable were it a comet in that position. In the next and final sweep I brought into the field what I supposed to be ζ Cancri, although it appeared very much brighter than what I expected from the appearance of δ Cancri which I had seen in the first sweep. I proceeded to record its position on the circles with the designation *b*. Before this was completed the total eclipse was over, and I ran across to where Professor Newcomb was observing in hopes of being able to point his larger instrument upon the star *a* before the light became too bright. I found, however, that he had a suspicious star in the field, and was then engaged in making the circle readings, so that his telescope could not be disturbed. I then went back to my own telescope, but the sunlight was already too intense to enable me to see the star last in the field. I did not therefore determine whether the instrument had been disturbed by a gust of wind from the west which came just before the sun reappeared. The telescope was clamped pretty tight in declination but it had a freer motion in right ascension. It was placed in the lee of a sand ledge and it was, hence, quite well protected from the wind. Sections of snow fence belonging to the railroad had

also been placed along this ledge as a more complete protection in case of very strong winds.

Upon reading the circles and reducing the observations, it is rendered probable that the telescope was disturbed in this instance; but I give the observations as they were made complete, in order that they may be made available in any future discussion. The places of the sun were again recorded and verified, and thus the position of the star *a* (which I believe to be an intra-Mercurial planet) can be determined relatively to the sun. The linear distances on the paper discs were roughly measured immediately after the observations, and the result was to show that the object which I had designated by *a* on the circles is not a known star. Since my return to Ann Arbor, I have placed the paper discs on the axis of a graduated circle, and setting them by means of a pointer, I have read off the positions. They are shown by the following table, in which the readings given are the mean of five readings on each mark:

Chronometer Time.	Object observed.	Circle readings.
$4^h\ 39^m\ 50^s$	Sun	$168°\ 16'{\cdot}3$
4 48 56	Planet (a)	163 50·9
4 50 5	ζ Cancri (b)	158 49·5
4 55 10	Sun	164 24·6
5 4 50	Sun	161 52·3

The three comparisons of (a) with the sun give

	Planet — ⊙. Δa.
(1)	$-8^m\ 35^s{\cdot}6$
(2)	$-8\ \ 28{\cdot}8$
(3)	$-7\ \ 59{\cdot}6$

The mean is

$$\Delta\alpha = -8^m\ 21^s.$$

The difference in declination measured on the circle is

$$\Delta\delta = -0°\ 22'.$$

The place of the sun for the instant of observation is

$$\alpha = 8^h\ 35^m\ 56^s. \qquad \delta = +18°\ 38'{\cdot}4.$$

and hence we derive

Washington Mean Time.	Planet's apparent a.	δ.
1878, July 29, $5^h\ 16^m\ 37^s$.	$8^h\ 27^m\ 35^s$.	$+18°\ 16'$.

It was not possible in the brief period of totality to change the eye-piece in order to observe the object under a high power. I can only state in addition to the above, that the appearance of the object arrested my attention even before I moved the telescope to the known star farther to the eastward. It was

very much larger than this star, which was θ Cancri, and its light was quite red. The appearance of the disc was such as to lead me to believe that it was situated beyond the sun.

I have not had an opportunity to make any calculations sufficient to determine whether the place observed can be reconciled with the reported observations of spots supposed to have been planets in transit across the sun. This I will do hereafter.

The star marked (*b*), and supposed to be ζ Cancri, was 0° 35′ south from the sun, as determined from the place marked on the paper circle. If the telescope was disturbed by the wind before the pointing was marked, the disturbance would probably be wholly in right ascension, since the motion in declination was pretty nearly clamped. In regard to the star (*a*), which I consider to be the planet sought, there is no uncertainty whatever, beyond the unavoidable errors of the record as made. I consider the place given to be trustworthy within 5′ of arc. It is to be hoped that persons who have made suitable photographs during the totality will examine the plates carefully in the region indicated. It is possible that the planet may appear upon some of them.

My station for observation was at Separation, Wyoming Territory, on the Union Pacific Railroad. It is near the summit of the Rocky Mountains, in a circular walled plain of several miles diameter, at an elevation of about 7,200 feet above the level of the sea. It is proper to add further, that the major part of the expenses of my expedition were defrayed by the U. S. Naval Observatory from the appropriation made by Congress for the observation of the eclipse.

Ann Arbor, August 13, 1878.

ART. XXVI.—*New Pterodactyl from the Jurassic of the Rocky Mountains;* by Professor O. C. MARSH.

THE Pterosaurian remains hitherto discovered in this country are all from the Cretaceous, and most of them belonged to animals of gigantic size. So far as known, they were all destitnte of teeth, and hence belong to the order *Pteranodontia.* A characteristic specimen recently found in the Upper Jurassic of Wyoming, and now in the Yale College Museum, is the first indication of this group of reptiles from this formation in America. The specimen, which is in good preservation, is the distal portion of the right wing metacarpal, and indicates a small pterodactyl having a spread of wings of four or five feet. The shaft of this bone at its upper portion is oval in transverse section, but near the condyle it is sub-trihedral, with a distinct

ridge on the under surface. The shaft is hollow, and the walls are thin and smooth. The outer condyle is placed obliquely, as in the Cretaceous species, and the lower groove between the two condyles is unusually narrow. The inner condyle is nearly circular in vertical outline, and its articular portion extends over about three hundred degrees.

The principal dimensions of this specimen are as follows:

Length of portion preserved	32·0mm
Transverse diameter of shaft where broken	4·5
Antero-posterior diameter	3·5
Transverse diameter of shaft immediately below condyle	5·
Antero-posterior diameter,	4·
Greatest transverse diameter across condyles	7·5
Vertical diameter of inner condyle,	8·
Antero-posterior extent of outer condyle	7·5

This interesting specimen was discovered in the Atlantosaurus Beds of Wyoming, by Mr. S. W. Williston. Its generic relations cannot at present be determined, but the species represented may be named *Pterodactylus montanus*.

Yale College, New Haven, August 17th, 1878.

SCIENTIFIC INTELLIGENCE.

1. *Descriptive Geology;* by ARNOLD HAGUE and S. F. EMMONS; Vol. II of *Geological Reports of United States Geological Exploration of the 40th Parallel*, CLARENCE KING, Geologist-in-Charge. 890 pp. 4to, illustrated by 26 plates. Washington, 1877. Submitted to the Chief of Engineers and published by order of the Secretary of War under Authority of Congress.—The publication of this Report was announced in the last volume of this Journal, and at the same time it was stated that a review of its chief results was expected for another number. The expected article has not been received; and as the volume is of special importance in connection with American Geology, a notice is here given without further delay.

The region explored is a very extended one, it reaching from the eastern Colorado range to the Sierra Nevada, with a width of about a hundred miles along the 40th parallel. The authors state that the seven years engaged in the work, from 1867 to 1873, was sufficient to make only a geological reconnaissance, rather than a finished systematic survey. Still, the account of the region is remarkably complete for a reconnaissance of such an area; and the whole is presented so clearly and systematically, both as regards the physical aspect, topography and geology, the general features and details, that the volume will be found a most acceptable one by the general public as well as the geologist. The descriptions commence with the eastern portion of the area, and

are given in five chapters corresponding to the five maps of the Atlas illustrating the region.

The *first* chapter treats of the Colorado range, its mountains, plains and rocks, the Laramie Plains, Medicine Bow Range, the North Park and Park Range, the Bridger's Pass Region, the Elkhead Mountains and the valleys of the Yampa and Little Snake Rivers; the *second* chapter, of the Green River Basin; the *third*, of the Utah Basin; the *fourth* of the Nevada Plateau; and the *fifth*, of the Nevada Basin. The facts cited relate mainly to the rocks.

The Laramie Hills described by Mr. Hague in the first chapter, include the part of the eastern Colorado range mostly within the limits of the 41st and 42d parallels. The altitude of the peaks is generally between 7,800 and 8,300 feet, one of the peaks reaching probably a height of 9,000 feet. This part of the range is an anticlinal, having an axis of granite and granitoid rocks of Archæan age, on either side of which lie unconformably sandstones and limestones of the Paleozoic, which dip away from the range at an angle of four to ten degrees. The Archæan rocks are coarse granites (consisting of quartz, orthoclase, some mica and usually a triclinic feldspar), passing above into a series of distinctly bedded "reddish granitoid rocks composed of quartz and feldspar," and becoming to the north and south decidedly schistose, being well-defined gneisses and schists. The rock disintegrates rapidly, as is well seen along railroad cuts, made within a few years. In two analyses of the granite less than one per cent of lime was obtained, and in another 1·40 per cent, showing, as Mr. Hague remarks, that the triclinic feldspar must be either albite or oligoclase. The mica is biotite, but with some lepidomelane. Iron Mountain is a mass of ilmenite or titanic iron. East of Iron Mountain there is a labradorite granitoid rock, with cleavable labradorite, described by Professor Zirkel, in his Survey Report, as gabbro. The amount of foliated pyroxene is small. On the west side of the Hills, graphite occurs in thin beds and seams.

The geological features characterizing the Laramie Hills continues southward along the Colorado Range. The granite of the summit of Gray's Peak afforded on analysis the same composition essentially as that of the Hills. The overlying sedimentary formations bordering the mountain range are estimated to have a thickness of about 6,000 feet; the Paleozoic, 850; the Triassic, 800 to 300; the Jurassic, 200; the Cretaceous, 4,300 feet (300 feet of the Dakota group, 1,000 of the Colorado group, 1,500 of the Fox Hill, and 1,500 of the Laramie). The *Paleozoic* beds continue along the eastern foot hills for nearly 70 miles, and then disappear, none being found north of Colorado Springs. The *Triassic* beds consist of red sandstone with some red clays and thin beds of limestone, and, in some localities, irregular deposits of gypsum, two to twenty-five feet thick. The *Jurassic* beds are slightly reddish in tinge, with orange, purple and lavender-colored strata, which are mainly argillaceous, together with some

thin layers of limestone and gypsum. But the limit between this formation and the Triassic is stated to be uncertain.

The Medicine Bow Range is made up almost exclusively of Archæan crystalline rocks, including granites, gneisses, mica schists, hornblende schists, diorytes, argillytes, quartzytes, etc. The granite and gneiss contain much of a triclinic feldspar, and in some places zircons. At Cherokee Butte, there is an Archæan granite whose quartz grains, according to Zirkel, show evidence of wear, and hence of the metamorphic origin of the rock. Medicine Peak is a mass of white quartzyte rising about 2,000 feet above the surrounding country and having an eastward dip. It contains some cyanite. It is cut through by what appears to be dikes of a fine-grained dioryte. The Archæan quartzyte is underlaid conformably by argillaceous slates, dipping eastward, and this by a hornblendic schist. At Mill Peak, the quartzyte is and overlaid by a red conglomerate, and, above the conglomerate, quartzyte, partly calcareous.

The North Park and Park Range are described at length by Mr. Hague; only a few facts respecting the volcanic rocks are here cited. They are all, as observed also by others, Tertiary in age. They are chiefly rhyolytes, according to Professor Zirkel. Along the east wall of the Park, the lower spurs and foothills of the Medicine Bow Range are covered by them. The central point of eruption was probably on the slopes of Mt. Richthofen. The divide between Middle and North Parks, stretching between the two great Archæan ranges, is composed largely of trachytes and basalts. The Cretaceous sandstones have in some places been lifted by the erupted trachytes. East of Parkview Peak the eruptive rock of some of the hills is granitoid and porphyritic, though probably related to the trachytes. Zirkel calls the rock granite-porphyry. The eruptions are not older than Cretaceous. The basalt of the divide between the two Parks lies almost entirely westward of the trachytic region.

The Elkhead Mountains are described by Mr. Emmons. They are a group of high volcanic peaks, some over 10,000 feet above the sea-level. They include the north-and-south elevations of Whitehead Peak and Steves Ridge, and, crossing this, an east-and-west ridge of basalt, mainly nepheline basalt. The trachytes are sanidin-trachytes, but contain a considerable amount of augite and, in some places, chrysolite, as described by Zirkel. There seems to have been a transition from the trachytic outflows in Hantz Peak to basaltic. In the basalt of Bastion Peak occur, besides the ordinary constituents and nephelite, some chrysolite, and biotite. The account of the Green River Basin is by Mr. Emmons; and those of the Utah Basin and Nevada Plateau are by him and Mr. Hague. It is impossible to do the subject any justice in this place, and only a few facts are here cited. The elevation of the plateau increases westward from 4,300 to 6,000 feet, Ruby Valley, along the east base of the Humboldt range, being the highest portion. The valleys are mostly under Quaternary deposits, coarse

and fine. The ridges, which rise 2,000 to 6,000 above the level of the valleys, trend nearly north-and-south, are approximately parallel, and vary from five to ten miles in width. The older sedimentary strata are also concealed to a large extent by great outflows of Tertiary volcanic rocks, which have spread in all directions from the old lines of upheaval.

Between the Desert Region—an arm of the Salt Lake Valley lying to the west of the Aqui Mountains—and the first ridge called the Ibenpah Mountains, there are terraces at the heights 800 feet, 500 feet and 300 feet, above the Desert level, the second marked by calcareous tufa.

The Wachoe Mountains, rising out of the Gosi-Ute Desert, contrast with the north-and-south lines of Paleozoic ridges in consisting of a dark reddish-gray granite, dioryte and quartz-porphyry, and outside of these a Coal-measure limestone, and then andesytes and rhyolytes. The granite contains little quartz, and afforded Professor T. M. Drown only 55·53 per cent of silica, with 5·20 of potash, 4·84 of soda and 5·62 of lime. The so-called "andesyte" is really, not a hornblende rock (hornblende grains being exceedingly rare), but contains much biotite, along with a triclinic feldspar. One of the two agreeing analyses by Mr. Woodward obtained Silica 67·63, alumina 18·08, iron protoxide 2·17, magnesia 1·14, lime 3·16, soda 2·87, potassa 3·86, ignition 1·49=100·40, agreeing little with ordinary andesytes.

The East Humboldt Range is the main range of Central Nevada, and the highest between the Wahsatch of Utah and the Sierra Nevada. One of the peaks, Mt. Bonpland, has a height of 11,321 feet and several are over 10,000 feet. A mass of Archæan rocks —granites, gneisses, etc.—constitutes its axis, though striking obliquely across the range, and on either side of it are inclined, unconformably, Devonian and Carboniferous strata. There are numerous cañons in the limestone of the eastern slope. All the ridges of the plateau are described in detail in the Report, and also those of the Nevada Basin.

The Report makes an excellent companion volume to that on the Petrology of the 40th parallel by Zirkel, it explaining at length the geological relations of the rocks. Many chemical analyses of rocks are given, the most of them by Mr. R. W. Woodward. Besides the large and beautifully-colored Atlas already noticed in this Journal, there are many most excellent ambrotype plates in the text, which are remarkable for their topographic and geological interest.

2. *Flora Australiensis: a Description of the Plants of the Australian Territory.* By George Bentham, F.R.S., assisted by Baron Ferdinand von Mueller, F.R.S., &c., &c. Vol. VII. *Roxburghiaceæ to Filices.* London: Reeve & Co. 1878. 806 pp., 8vo. —This volume brings a great undertaking to a happy completion. The first volume was issued in the year 1863, and the work has made steady progress to the end. It is the complete phænogamous Flora of a continent, and the only one; is worked up by one

mind and hand, within a time and at an age which allows no sensible change of ideas or point of view, so that it is throughout comparable with itself. It is the work of the most experienced and wise systematic botanist of the day, and when we know that fully as much other work, of equal character, has been done within these fifteen years, it will not be denied that the author's industry and powers of accomplishment are unrivalled. No one else has done such good botanical work at such a rate. If, as some fear, the race of first-class systematic (phænogamous) botanists is destined to die out or dwindle, it will not be for the lack in our day of a worthy model.

In the concluding Preface, Mr. Bentham turns over to his able and equally indefatigable coadjutor, Von Mueller, the duty of incorporating addenda and corrections, and suggests the preparation of a methodical synopsis, for convenient use, especially in Australia, where such a hand-book will be most helpful and needful. This trust, we doubt not, Von Mueller will duly undertake, and may be expected worthily to accomplish. His fellow-workers over the world are not unmindful of their great obligations to him in the development of Australian botany, and in rendering practicable the production of this Flora Australiensis, which has been equally enriched by his vast collections and facilitated by his preliminary study of them.

Mr. Bentham now declines to undertake "a detailed examination of the relations, as well of the whole flora to that of other countries, as of its component parts to each other," referring instead to "the principles laid down by J. D. Hooker in the admirable essay prefixed to his Flora Tasmaniæ," but recapitulating shortly the general characteristics of the chief component parts of the present flora of Australia, the most peculiar one of any large part of the globe. Let us still hope that he may some day reconsider this determination, so far as to discuss in a general way the relations of Australian botany to the history of vegetation on the globe.

Peculiar as the Australian vegetation is, its treatment not rarely touches points which concern the student of the American flora. Especially interesting to us is the elaboration, in the present volume, of the *Gramineæ*, in which General Munro's matured views—as yet little known by publication—have passed under the independent consideration of a veteran general botanist, and in which the author's own conclusions regarding the morphology and terminology of the floral parts and their accessories are practically applied. We duly noticed Mr. Bentham's essay on this subject, and had to acknowledge that its conclusions are apparently incontrovertible.

Next to this order in importance is the order *Cyperaceæ*, upon the arrangement of which sound judgment is brought to bear. The great order *Liliaceæ* is made to include the *Smilaceæ*, and not the *Roxburghiaceæ*. We should have excluded both, but *Smilax* in preference. Contrary to Mr. Bentham's opinion, we

should insist that the anthers in *Smilax* are *unilocular* but *bilocellate*. The diagnosis of *Roxburghiaceæ* in the conspectus distinguishes the order from Australian Liliaceæ only, and by an oversight the second genus of the order is said to be restricted to Japan, whereas it was founded on a North American plant. A. G.

3. *Flora of Mauritius and the Seychelles: a Description of the Flowering Plants and Ferns of those Islands.* By J. G. BAKER, F.L.S., etc. London: Reeve & Co. 1877. 557 pp.—Another of the British Colonial Floras, complete in one volume. Contains 112 orders, not a few of which are represented mainly by naturalized plants, 440 genera, and 1058 indigenous species. Thanks to sugar-culture and bad management, the forests of Mauritius, "which at the time when it was named by the Dutch, in 1598, covered it to the water's edge, have been by degrees cut down, till they are now almost entirely destroyed. . . . . From 467 tons in 1812, the amount of sugar exported increased till it reached a maximum in 1860, so that it was calculated at that time that this island, with an area of 700 square miles, produced about a tenth of the exported sugar of the whole world. The consequence is that the indigenous flora of the island, as we have it now, is a mere wreck of what it was 100 years ago, ... and the interesting endemic trees and shrubs . . . . have either been entirely exterminated or become very rare, and that a crowd of introduced trees, shrubs, and weeds have replaced the original vegetation to a greater extent than in any other part of the world, except St. Helena." The number of introduced plants which have become established on the island is estimated at 269; that of indigenous flowering plants and ferns is 869. Rodriguez has probably suffered in the same proportion. It has now only 202 known wild species, 36 of which are peculiar. The Secheyelles, of 30 little islands, are less rich in peculiar plants than was expected: 338 wild species are known, of which 60 are peculiar. Six of them are Palms, of as many genera, *Lodoicea Sechellarum*, the *coco de mer* being the famous one. The Palms are elaborated by Dr. I. B. Balfour, the recent explorer of Rodriguez, the Orchids by S. L. Moore. We are pleased to learn that, since the publication of this volume, Mr. Baker has been elected a Fellow of the Royal Society. A. G.

4. *Forest Flora of British Burma.* By S. KURZ, Curator of the Herbarium, Royal Botanic Gardens, Calcutta. Published by order of the Government of India. Calcutta, 1877. 2 vols. 8vo. 1877.—Contains plain English descriptions of all the known woody plants of the district, about 2000 species, with an introductory sketch of the various kinds of forest, climatology, etc. When it is said that, "an evergreen tropical forest consisting of 200 to 300 species of trees to the square mile is almost the rule," it must be understood that shrubs are included. This work appears to be carefully done. A. G.

5. *The Apocynaceæ of South America; with some preliminary Remarks on the whole Family. With thirty-five plates, to illus-*

trate the structure of the Genera. By JOHN MIERS, F.L.S., etc. London, Williams & Norgate, 1878. 277 pp., 4to.—This venerable and indefatigable botanist has here newly elaborated a great part of an order which has in our day received attention from Alphonse DeCandolle, from J. Mueller, and lately from Bentham, in the Genera Plantarum. Many new genera are proposed, several suppressed or overlooked genera restored, their characters illustrated by the author's neat figures, and a new arrangement into classes and tribes proposed. Two of the classes are characterized by the stamens, but not sharply contrasted, the third rests upon the seed alone. In many respects the system differs widely from that of the Genera Plantarum. A. G.

6. *The Student's Flora of the British Islands.* By Sir J. D. HOOKER, K.C.S.I., C.B., etc. Second Edition. London, Macmillan & Co. 1878.—This new edition exceeds the old one by over thirty pages. We have not sought by comparison to ascertain the changes made; but there are indications of careful revision. The accentuation of names appears to be perfect, one or two omissions excepted. By why are not accents cast upon the types, instead of being interposed between them, making an ungainly break in the word? A really compact and portable flora like this is a great convenience. A. G.

7. *Botany of Kerguelen Island.*—A quarto of 86 pages and 5 plates, without title page, is received, being a part of the publication of the scientific results of the British expedition to observe the transit of Venus. It contains: 1, Observations on the Botany of Kerguelen Island, by J. D. Hooker, an interesting supplement to his former discussion of this isolated florula, strengthening the supposition of the derivation of the land plants from South America by means of former intermediate tracts of land; 2, Enumeration of the Plants hitherto collected, &c.; by the same author, except as to the Lower Cryptogamia. Of these, the *Musci* and *Hepaticæ* are by Mitten, *Lichenes* by Rev. J. M. Crombie, Marine *Algæ* by Professor Dickie, Fresh Water *Algæ* by Professor Reinsch, an elaborate contribution, and the few *Fungi* by Berkeley. A. G.

8. *Ferns of North America.* By Professor DANIEL C. EATON.—Parts VI and VII, issued as a double number, maintain the high character of the work for beauty and scientific exactness. *Polypodium aureum* is particularly well represented; so are the Grape Ferns (*Botrychium*), which here are in full force. The figure of *Pheyopteris Dryopteris* is very characteristic, but flat, without the least foreshortening; *Blechnum serrulatum* is so reduced as to convey no idea of its port; and *Adiantum pedatum* is somewhat thinnish. The paper and typography are sumptuous. A. G.

9. *A Manual of the Anatomy of Invertebrated Animals.* By THOMAS H. HUXLEY. 8vo, 596 pp. New York: D. Appleton & Co.—The American edition of this important work was issued some months ago, but was not noticed at that time. It is a val-

uable compendium, both of general and special anatomy of the invertebrata, which should be in the hands of every working naturalist. It is also well adapted for the use of special students pursuing biological studies in the laboratory, but is hardly suitable for a text-book for the class room, owing to the large amount of detail introduced in many cases, and the, perhaps, unnecessarily numerous technical terms made use of. It is freely and well illustrated. A. E. V.

10. *Manual of the Vertebrates of the Northern United States.* Second Edition. By DAVID S. JORDAN. 12mo, 407 pp. 1878.—The second edition of this work has been considerably enlarged, and many improvements have been made. The portion relating to the fishes has been largely rewritten, and the artificial keys in that group have been replaced by "natural" ones, for the genera. Most of the additions and corrections in other groups are to be found in the addenda. A. E. V.

11. *The Structure and Habits of Spiders.* By J. H. EMERTON. 12mo, 118 pp., with 67 cuts. Salem, Mass.: S. E. Cassino.—This excellent little book fills a place in our zoölogical literature hitherto entirely unoccupied. It contains very clear and interesting descriptions of the anatomy of spiders, their classification, their manners and customs and domestic economy. It is admirably illustrated by figures drawn from nature, by the skillful pencil of the author himself. Many of the figures illustrate the webs and nests of spiders with remarkable accuracy. A. E. V.

12. *First Annual Report of the United States Entomological Commission, for the year* 1877, *relating to the Rocky Mountain Locust.* With maps and illustrations. 8vo, 771 pp., 5 plates. Washington, D. C., 1878.—This extended report contains a history of the ravages of locusts in this country, with statistics, their geographical distribution, migrations, etc.; detailed descriptions of the species and others closely allied, their metamorphoses, habits, parasites, anatomy, histology, etc.; a detailed account of the various means of destroying them or diminishing their numbers, and accounts of the effects that follow their ravages; accounts of ravages of locusts in other countries; also numerous appendices, containing various collateral information. Three of the plates, drawn by Mr. J. H. Emerton, well illustrate the growth and metamorphoses of the Rocky Mountain locust, and two other closely related species of Caloptenus; the fourth plate, by Mr. C. V. Riley, illustrates their parasites; and the fifth, by Mr. C. S. Minot, illustrates the histology. A large part of the volume is devoted to the practical bearings of the subject upon the agricultural interests of the country. A. E. V.

13. *On the young stages of Osseous Fishes.* By ALEXANDER AGASSIZ. (From the Proceedings of the American Academy of Arts and Sciences, vol. xiv.) 8vo, with 8 plates. June, 1878.—This paper contains the results of the extended and careful studies of the author upon the growth and metamorphoses of this peculiar group of fishes, including the results of various experiments made

to test the effects of environment upon their colors, etc. The phenomena connected with the changes in the position of the eyes, and the asymmetry of the body are fully described and illustrated. The sensitiveness of the young flounders to the character of the light or color of surrounding objects, and their remarkable powers of imitating such colors are well discussed. A. E. V.

14. *Results of the Recent Eclipse;* by Professor C. A. YOUNG. (From the New York Times, of August 16.)—It is early, as yet, to estimate the full scientific meaning and value of the observations made during the recent solar eclipse, but it is already evident that, though in some respects disappointing, they are yet, on the whole, of an importance quite equal to those obtained on any similar occasion.

One brilliant discovery will probably date from this occasion, and hold a conspicuous place in the annals of science. The planet Vulcan, after so long eluding the hunters, showing them from time to time only uncertain tracks and signs, appears at last to have been fairly run down and captured. At least it seems to us that the observations of Professor Watson at Rawlins, and Swift at Denver, must for the present be taken as conclusive, though perhaps not settling the question beyond the possibility of reopening or dispute. The gentlemen are both astronomers of repute, accustomed to sweep for faint objects, and provided with excellent instruments. The negative results of Professors Newcomb, Wheeler, Holden and others, who with similar instruments, went over the same ground and found nothing, are, indeed, unsatisfactory and puzzling; but they can hardly outweigh the positive evidence on the other side, though they certainly justify a certain reserve in accepting the conclusion.

Assuming as correct Professor Watson's estimate of the planet's brightness (four and a half magnitude), it would be more than forty times fainter than Mercury, and considering its proximity to the sun (which would make it much brighter than if at the same distance as Mercury), it would seem that its diameter must be somewhere between 200 and 400 miles. If really thus minute, it is easy to see how it has so long escaped discovery; indeed, the question at once arises whether there must not be several such Vulcans, to account for that peculiar behavior of Mercury, which led Leverrier, on purely mathematical grounds, to assert the existence of a planet or planets between Mercury and the sun. Mr. Swift, in fact, claims to have seen two bodies—Watson's and another near it.

It is unfortunate that the single observation of Professor Watson cannot give definite information as to the orbit and motions of the planet; but for this purpose at least three observations are needed, and unless (as Professor Watson hopes to do) he succeeds in identifying some of the many recorded transits of small black objects across the solar disk, as observations of his planet, it may be long before we shall know anything further about it. There is, however, a bare possibility that it may be recovered in full daylight by arming a large telescope with a very long tube, pro-

jecting beyond the object glass, and thus enabling the observer to examine the sky within a degree or two of the sun without letting the sunlight fall upon the lens. If the experiment could be tried at a considerable altitude, where the atmospheric glare is at a minimum, the chance of success would be greatly improved.

As regards the physics of the sun and the corona, the principal and most important result of all the observations bearing upon this subject is to demonstrate a decided sympathy and connection between the condition of the sun's visible surface, as indicated by the number and character of the sun spots, and the constitution of the corona.

At the present time the sun's spots are at their minimum; whole months have passed without the appearance of a single one. The chromosphere, or colored envelope of hydrogen and other gases which immediately surrounds the sun, has also been correspondently quiescent, and the so-called "prominences" have been few and small. Of course it was a question of interest whether the corona also would show a corresponding difference of condition from that indicated in 1869 and the later eclipses, when the Sun's surface was in full activity, and the question has received an emphatic and affirmative answer.

As to the brightness of the corona at the recent eclipse, there is considerable difference of opinion. The writer, and he thinks a large majority of those who also saw the eclipse of 1869, is strongly of the impression that in 1869 the corona, though perhaps less extensive, was many times more brilliant, while the corona in 1870 seemed to him intermediate between those of 1869 and 1878. Some of the best observers, however, are of quite the contrary opinion, and it is frankly to be admitted that one's judgment as to the brightness of an object like the corona depends so much upon the condition of the eye at the moment of observation, and that condition so depends upon what the eye has been doing for the last few moments preceding, that no very great weight is to be assigned to such impressions. The writer feels, however, considerable confidence in his estimate of the relative brightness of the three eclipses, because in all three cases his observations were made under almost precisely similar circumstances—near the middle of the eclipse, and after about a minute of close spectroscopic work.

While, however, there may be room to question the conclusion that the corona this year was uncommonly faint, there can be no question that its spectrum was profoundly modified.

The bright lines which come from its gaseous constituents were conspicuous in 1869 and in all the subsequent eclipses until the present one, but this year they were so faint as to be seen by only a few of the observers, while the great majority missed them entirely, seeing only a continuous spectrum. This was especially remarkable in the case of the green corona line (known as "1474" from its position upon Kirchhoff's map of the solar spectrum). Many observers saw it plainly just at the beginning and end of totality, but during the middle of the eclipse nearly all entirely

lost sight of it. That it was really present all the time, however, though faint, is proved by the observations of Professor Eastman, Professor Brackett, Mr. Thomas and the writer, the former of whom traced it all around the sun to a distance of from 10′ to 20′, going twice over the ground, and keeping it in sight all the time. With the hydrogen lines the case was similar; the writer had one or other of them in the field continually, and they never quite disappeared, though at times very faint.

Of course, the slitless spectroscopes, both ocular and photographic, from which so much had been expected, failed to give any satisfactory results. In 1871, when the instruments were first used, the observers saw a series of colored images of the corona. Mr. Lockyer, for instance, saw four such images, one red, one green, one blue, and one violet. This year nothing of the kind appeared. At the moment, indeed, when totality began there was an exquisite exhibition, first of the darkness of the solar spectrum, and then for an instant of a multitude of bright colored segments—the spectrum of the chromosphere; but when the moon had covered the chromosphere there was only a disappointing, continuous band of color, unmarked by rings of any kind.

Those, also, who were looking for new bright lines in the corona spectrum were equally unsuccessful, whether they employed the ordinary spectroscope or worked by photography. Some of the observers, the writer among others, used a so-called "fluorescent eye-piece," which brings the otherwise invisible light beyond the extreme violet-end of the spectrum within the range of human eyes, by the action of a film of fluorescent liquid (æsculin solution) inclosed between thin plates of glass. But, although before totality the apparatus worked perfectly, disclosing to the eyes dark lines innumerable in the portion of the spectrum invisible without its aid, after the darkness came on it failed to show a single bright line. The most carefully prepared and sensitive photographic apparatus succeeded no better, except that Dr. Draper, Mr. Lockyer, and one or two others perhaps, did obtain by means of a slitless spectroscope, an impression of a faint continuous spectrum in the ultra violet, without rings or markings of any kind. Evidently no lines existed to see or photograph on this occasion.

One or two observations were made of some interest in their relation to previous work. Professor Rockwood, of the Princeton party, using a double-barreled slitless spectroscope, observed at the beginning of totality a bright red line in the chromosphere spectrum very near to B. This explains an observation of Mr. Pogson, in 1868, who then insisted that he saw B reversed in the spectrum of a prominence, but as all the other observers had C instead of B, his record was generally regarded as a mistake.

The line is probably one well known to solar spectroscopists, at 534 of Kirchhoff's scale—a line exceedingly difficult to see in the spectrum of the chromosphere under ordinary circumstances, but still invariably present and exhibitable (if one may coin a word) with proper appliances. Its conspicuousness in Professor Rockwood's instrument is a matter of some surprise, but there could be

no mistake, as C was even more brilliantly conspicuous at the same time. What the substance which causes it may be is quite unknown. Like the so-called D_3 line it has no corresponding dark line in the solar spectrum.

The same observer, and the writer also, saw both H lines (calcium) brightly reversed in the spectrum of the chromosphere; thus confirming observations made six years ago at Sherman, but never corroborated since, except by the photographic spectrum obtained by the Siam expedition in 1875.

The exquisite reversal of the dark Fraunhofer lines at the moment of totality was seen by many of the observers. Several observers, especially Professors Barker and Morton, at Rawlins, were able to confirm Janssen's observation in 1871 by seeing the principal dark Fraunhofer lines in the corona spectrum, thus showing that a considerable percentage of the coronal radiance is mere reflected sunlight. The dark lines were, however, so faint as to be seen by very few, and this shows equally clearly, we think, that the particles which reflected the sunlight are themselves also self-luminous, as, of course, they ought to be so near the sun.

A great deal of attention has been paid to the polarization of the coronal light in past eclipses, and while on the whole there has been an overwhelming weight of evidence in favor of radial polarization, yet at every eclipse some observer of reputation has obtained anomalous results quite at variance with all the others. This year Dr. Hastings of Baltimore, comes out with strong tangential polarization as his result. That he must be the victim of some mistake is almost certain, since all the rest of the observers—Wright, Ranyard, Harknesss and others—are emphatic and clear in their contrary conclusion.

Experiments with the tasimeter or new heat measure of Mr. Edison showed, as was ascertained many years ago, that the heat of the corona is quite sensible. With a thermopile attached to a peculiarly-arranged spectroscope Mr. Anderson, of the Princeton party, obtained a doubtful result, which may indicate a bright heat-line in that part of the chromosphere spectrum below the red.

It has been represented in some quarters that the results of this eclipse require a fundamental reconstruction of the theories hitherto held regarding the constitution of the corona. This is, however, an entire misapprehension. The same constituents appear in the corona as hitherto, only in altered proportions, as might have been and was expected by students of solar physics. In 1869, 1870 and 1871 the gaseous elements of the corona—the hydrogen and "1474 stuff," whatever that may be—were in such quantity and condition and rose so high above the solar surface that their lines were conspicuous in the coronal spectrum, and attracted the attention of observers far more forcibly than the feeble continuous spectrum of the light emitted from and reflected by, the minute solid or liquid particles which also constitute an essential element of the corona. At present the condition is reversed. The gases are either too small in quantity or too cool to be conspicuous. The lesson, and it is an important one, is simply,

as has been said, that, to a certain extent, the corona sympathizes with the sun-spots.

It certainly looks probable, also, that while the gaseous elements of the corona are strictly solar, the non-gaseous matter—the coronal dust or haze—is of extraneous and very likely meteoric origin. At any rate, the extent of the corona was certainly not less than on former occasions, whatever may have been the case with its brightness. In fact, it has never been traced quite so far from the sun before, as this time by Langley and Newcomb, who followed it out for six degrees along the ecliptic, a success partly, of course, due to the clearness of the air at their elevated stations. Now, this is quite consistent with the theory that meteor streams furnish the hazy matter of the coronal envelope, since, so far as we can judge, they have nothing to do with the sun-spots.

A very interesting problem relates to the effect of solar forces upon this meteoric matter, if such it really be, and the material for the study is furnished in rich abundance by the numerous drawings made by Langley, Abbe, Penrose, Boss and others, and by the photographs, which in excellence and number excel those obtained on any previous occasion. Among the best which we have seen are the magnificent series made by Rogers at La Junta, those of Draper at Rawlins, and those of the Princeton party at Denver; undoubtedly there are others of at least equal excellence.

To sum up: The eclipse of 1878 has added a new planet to the system, and has demonstrated that the unknown cause, whatever it may be, which produces the periodical sun spots at intervals of about eleven years, also affects the coronal atmosphere of the sun.

This, of course, adds a certain measure of probability to the idea that these solar periods may produce some effect upon the earth, such as may be felt in our meteorological conditions; and though the writer by no means concurs with Mr. Lockyer in considering that Meldrum's investigations upon Indian cyclones have already demonstrated connection between the sun spots and the weather, but, on the other hand, thinks the connection almost disproved by results of other investigators, still there can be no question that the subject deserves thorough study.

The result of the late eclipse goes to show such a periodical change in the state of the solar atmosphere as might very possibly produce a sensible effect upon the earth; whether it does or not is a question which can be settled only by a careful and systematic investigation of the facts.

Princeton, N. J., Thursday, Aug. 15, 1878.

15. *Institute of France.*—Dr. Asa Gray has been elected Corresponding Member of the Institute in place of Alexander Braun, of Berlin, recently deceased.

Charles Darwin has also been made a Corresponding Member of the Institute.

16. *The Annual Meeting of German Naturalists and Physicists* will be held during the week from September 11–18, instead of the following week.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

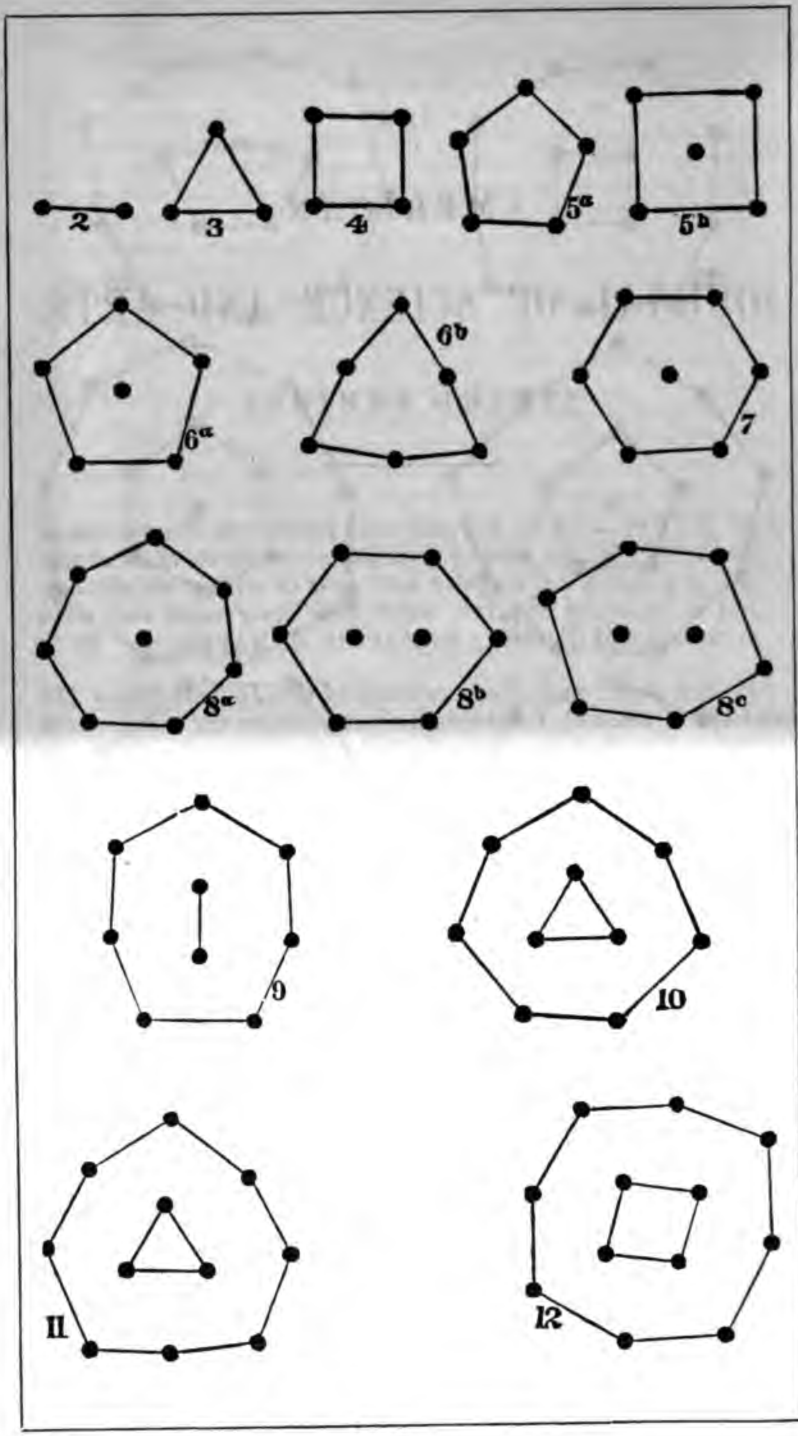
[THIRD SERIES.]

ART. XXVII.—*On the Morphological Laws of the Configurations formed by Magnets floating vertically and subjected to the attraction of a superposed magnet; with notes on some of the phenomena in molecular structure which these experiments may serve to explain and illustrate*; by ALFRED M. MAYER.

IN the April and June numbers of this Journal (pages 276 and 477 of vol. xv), I published short notes on my experiments with magnets floating vertically and subjected to the attraction of a superposed magnet. The object of this paper is to present accurate diagrams of the configurations formed by the floating magnets and to give the laws ruling these configurations, with some notices of the peculiarities of these forms. At the same time I will show how neatly these experiments illustrate several phenomena in the molecular structure of matter.

*The Diagrams.** —These diagrams show the configurations formed by numbers of magnets extending from two to twenty. They were obtained as follows: the number of needles forming a configuration were floated in a bowl filled to its brim with water. The eye ends of the needles, which protruded a short distance beyond the tops of the corks, were of S. polarity. A cylindrical magnet, 38^{cm} long and 15^{mm} in diameter, was clamped in a vertical position, with its N. end at the constant distance of 60 millimeters above the tip of the needle which floated in the line of the axis of the magnet. I tipped the ends of the needles with printer's ink, and when the configuration had formed and was stationary, I brought down upon the needles a piece of flat card-board, and thus obtained prints

* I am indebted to the courtesy of Mr. A. E. Beach, of the Scientific American, for the use of the engravings of the diagrams which illustrate this article.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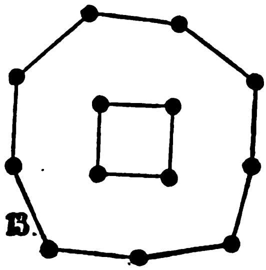

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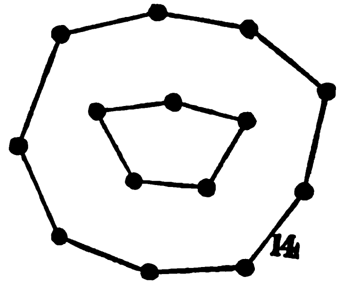

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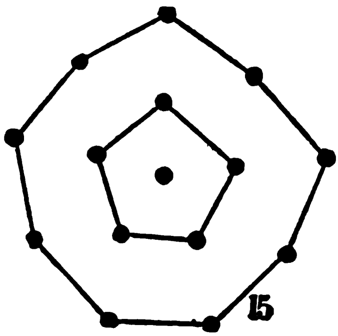

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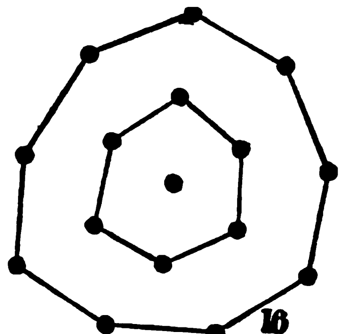

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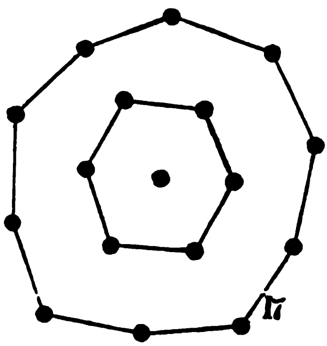

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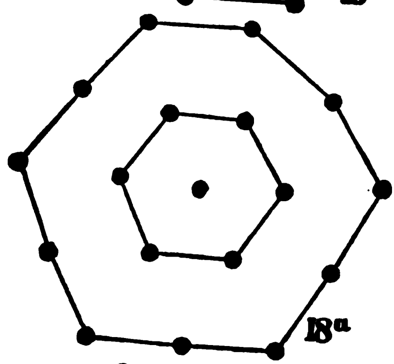

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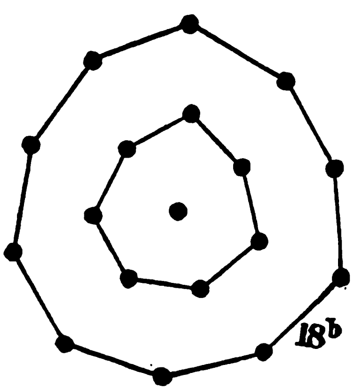

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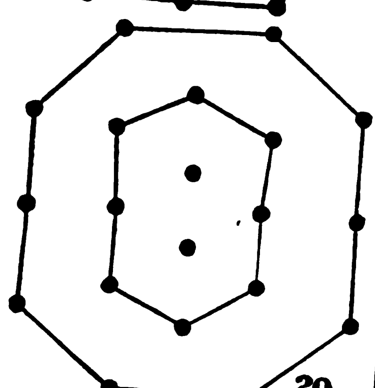

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from nature. Around each of the dots on the card-board I drew a black disk. The centers of these disks I joined by lines, in order to bring before the eye the contours of the configurations. After the diagrams of the configurations had been obtained in this way they were placed at a fixed distance from the camera, and photo-engravings were thus made of about one half the sizes of the original prints.

The Morphological Laws of the Configurations.—The configurations made by the floating magnets form well marked groups or classes, which may be designated in order as primary, secondary, tertiary, quaternary, etc. The stable configurations of one class form the nuclei to the succeeding ones.

Looking at the diagrams the reader will see that figures 2 to 8*a* inclusive form the *primaries.* Figure 8*b* begins the secondaries, for it is the hexagon with 2 for nucleus. Configurations 8*b*, 8*c*, 9, 10*b*, 10*a*, 11, 12, 13, 14, 15, 16, 17, 18*a*, 18*b* and 19*a* are *secondaries*, having respectively for nuclei the primaries 2, 2, 2, 2, 3, 3, 4, 4, 5*a*, 6*a*, 7, 7, 7, 8*a*, 8*a*. The configuration 10*b* is not found in the diagrams; it is the same as the 10 which forms the nucleus of 20, only the two central lateral needles are further removed outward from the vertical axis of the fig. 10.

The group of 19*b* begins the *tertiaries.* Of these I do not give diagrams, but indicate their structure by giving the numbers of the secondaries forming their nuclei and then give the numbers of needles grouped around these nuclei. Thus, the structure of the configuration formed of 47 needles is indicated by $47=(18+14)+15$; which means that 47 needles form a configuration which has 18 for its inner nucleus, surrounded by 14 needles, and these in turn surrounded by 15; and as $18+14$ forms the tertiary which is the nucleus to this quaternary 47, we inclose 18 and 14 in parenthesis.

I here give the configurations to 51 inclusive, which form begins the quinaries.

The configurations of the same number of magnets are lettered *a*, *b*, *c*, to indicate their degrees of stability; *a* being always the most stable form. I have, however, lettered the configuration of 8 magnets in the order of their increasing areas in order to make them serve better for the purpose of illustrating the phenomena of isomerism. Really, 8*c* is more stable than 8*b*.

Tertiaries.

19*b* = 9 + 10	25*a* = 12 + 13	29*b* = 17 + 12
20*a* = 9 + 11	25*b* = 13 + 12	30*a* = 17 + 13
20*b* = 10 + 10	26*a* = 13 + 13	30*b* = 18 + 12
21*a* = 10 + 11	26*b* = 14 + 12	31 = 18 + 13
21*b* = 11 + 10	27*a* = 14 + 13	32 = 18 + 14
22 = 11 + 11	27*b* = 15 + 12	33 = 18 + 15
23 = 11 + 12	28*a* = 15 + 13	34*a* = (8*a* + 12) + 14
24*a* = 12 + 12	28*b* = 16 + 12	
24*b* = 11 + 13	29*a* = 16 + 13	

Quaternaries.

34*b* = (9+10)+15	40 = (13+13)+14	47 = (18+14)+15
35*a* = (9+12)+14	41 = (13+13)+15	48 = (18+15)+15
35*b* = (10+12)+13	42 = (13+14)+15	49 = (18+15)+16
36 = (10+12)+14	43 = (15+14)+14	50 = (8+11+15)+16
37 = (10+13)+14	44 = (15+14)+15	51*a* = (8+12+15)+16
38 = (11+13)+14	45 = (16+14)+15	
39 = (11+13)+15	46 = (18+14)+14	

Quinaries.

51*b* = (9+12+14)+16

I do not say that the above list contains all the possible combinations. The list is more for the purpose of establishing the laws which I have already formulated.

In my first publication I gave two configurations for four needles; one having the needles at the corners of a square, and a stable form; the other unstable and formed of a triangle containing a central needle. I have concluded that this form does not exist; at least, its existence is so transient that it has never remained long enough for me to take a print of it.

I have stated that 19*b* begins the tertiaries. This is an unstable configuration, and is formed of 9 surrounded by 10 magnets. The other 19, 19*a*, is stable, and is formed of 8*a* surrounded by 11 magnets. It is to be remarked that not alone the tertiaries but the configurations in the other classes begin with an unstable group of magnets. Thus, 8*c* begins the secondaries, 19*b* the tertiaries, 34*b* the quaternaries, and 51*b* the quinaries.

The reader has seen that a given number of magnets may form two or more different configurations. Thus, five magnets form two, 5*b* a square with a magnet at its center, and 5*a* a pentagon. Six magnets give 6*a* and 6*b*. With eight magnets we obtain three configurations, 8*a*, 8*b*, and 8*c*. Now the different configurations formed of the same number of magnets always exhibit different degrees of *stability*. Vibration of the less stable forms (produced by alternately lifting and lowering the superposed magnet) sends them into the stable forms. Thus, 5*b* on vibration rearranges itself into 5*a*; 6*b* into 6*a*; and 8*c*, or 8*b*, into 8*a*. With the configurations of higher classes (the tertiaries, quaternaries, etc.), even a knock on the table is sufficient to cause the needles of the unstable configuration to move to positions of stable equilibrium.

On looking at the diagrams it will be observed that only the *stable* primaries form the nuclei of the secondaries, and, moreover, those primaries which are not dimorphous, like 2, 3, 4 and 7, serve as nuclei to more than one secondary. Thus, 2 is the nucleus of 8*a*, 8*b*, 8*c*, 9 and 10*b*: 3 is the nucleus of 10*a* and 11; and 7 is the nucleus to 16, 17 and 18; while each of the other stable and dimorphous primaries, 5*a*, 6*a* and 8*a*,

appears only once, as nucleus respectively to 14, 15 and 18*b*. This same power of the most stable nuclei to resist outside stress is shown in the configurations of the tertiary and quaternary classes, where the secondary 11 appears as nucleus to 21, 22, 23 and 24. The secondary 18*a* persists in even a more marked manner as a nucleus. This 18*a* has the contour of that very stable 7 (the only configuration possible with 7 magnets), which forms its nucleus. Among the tertiaries 18*a* is the nucleus of 30*b*, 31, 32 and 33, while in the quaternaries it forms the inner nucleus of 46, 47, 48 and 49. The fact of the persistence of these stable forms as nuclei may be suggestive to chemists and crystallographers.

It is here to be remarked that (as a general rule holding good in all the classes) of two configurations made up of the same number of magnets, that configuration is the more stable which has the least number of needles for its nucleus.

Illustrations of Molecular Structure. (1.) *Unstable Molecular Equilibrium.*—That the molecules in a body may be in a state of unstable equilibrium, so delicately balanced that a slight extraneous action of pressure, of heat, light, etc., may cause a new molecular arrangement in the body, is shown in many facts. A few of the more familiar ones will answer for our purpose. Thus, quiet water, which remains liquid at a temperature of 10° C., or more, below 0° C., changes suddenly into ice when agitated; and during this solidification its temperature rises. In like manner a supersaturated solution of disodium sulphate solidifies when a crystal of this substance is dropped into it. Another instance of a sudden change from an unstable to a stable molecular condition is shown when the yellow crystals of mercuric iodide change, on the touch of a glass rod, to a scarlet color with a perceptible motion of their particles. These and similar phenomena are illustrated by the change of unstable to stable configurations caused by vibration, shock, and varying conditions of stress. Thus, 5*b* changes into 5*a*; 6*b* into 6*a*; and 8*c* and 8*b* into 8*a*.

(2.) *Illustrations of the Expansion on Solidification*, as shown by water, bismuth, antimony, cast-iron, etc., are readily given by the floating magnets. One volume of water at 0° C. expands on freezing into about one and one-tenth volume of ice. It happens that the area of 5*b* is greater than the area of 5*a* by about one-tenth; so that the increase in area which takes place when the pentagon of 5*a* is changed into the square 5*b* may represent the increase in the volume of water when it changes into ice.

It will be observed, on an examination of the diagrams, that of two configurations, formed of the same number of needles, that configuration which has the larger area has a magnet in its

center. Thus, 5*b* exceeds in area 5*a*, and 6*a* is of greater area than 6*b*. To see the effect of a repulsive center on a configuration, compare the areas of the two squares 4 and 5*b*, and of the two pentagons 5*a* and 6*a*. The most marked effect of a repulsive central magnet is seen on comparing 14 with 15. The outside contour of each is formed of 9 magnets. The nucleus of 14 is the peculiar flattened pentagon, which is expanded into symmetry on the addition of another magnet, while at the same time the outside contour of 15 conforms to the regular pentagonal nucleus. These phenomena are so suggestive that I make bold to put the question: may it not be that there is an actual *centralization* of atoms in the molecule when a body expands in solidifying, and in the case where of two or more isomeric bodies one has always the minimum density? I offer this as a suggestion which may be worthy of the consideration of crystallographers.

(3.) *Illustrations of Allotropy and Isomerism.*—The most interesting of our experiments with the floating magnets are those illustrating the phenomena of allotropy and isomerism. It is well known that an elementary substance may exist under very different forms. By the action of heat, electricity, etc., an element may have its physical and chemical properties so changed that no one would suppose that the different bodies thus made out of one and the same element were really all of the same substance; yet the body remains elementary under the different appearances, for it is impossible by any means of subtraction to get anything but the elementary substance from it. Phosphorus, sulphur and carbon give instances of allotropy. Thus graphite and the diamond are both carbon, yet how different are they. One is soft, opaque, black, and with a metallic luster; the other is the hardest of bodies, transparent, and resplendent by its refractive action on light. Graphite is a good conductor of electricity; crystallizes in small six-sided tables which belong either to the hexagonal or monoclinic system, and have a specific gravity of 2·2; while the diamond is a bad conductor of electricity, crystallizes in the monometric system, and has a specific gravity of 3·5. Whenever an element or a compound takes two different crystal forms, these different crystals always differ in their density.

These differences of form and density shown in allotropy and isomerism are well illustrated in the configurations which are formed of the same number of magnets. Take figures 5*a* and 5*b*. The first is a pentagon. The second is a square with a magnet in its center. The forces in these floating magnets and in the superposed magnet remain the same in all the configurations, and these have all been printed from needles floated in water whose surface was at a constant perpendicular distance

from the pole of the superposed magnet. Thus we see how the same atoms endowed with forces of the same strength, may take different relative positions, and thus produce very different crystal-forms in the same matter. We may take 5*a* for an illustration of the atomic arrangement in the diamond, while 5*b* may stand for graphite. But there is always a change of density accompanying the different forms in allotropy, and this fact is also illustrated by configurations 5*a* and 5*b*. In bodies formed of the same kind of elementary atoms, as in allotropy, it is evident that their relative densities will be directly as the number of atoms contained in the unit of volume. As our configurations illustrating allotropy contain the *same* number of magnets, it follows that the *relative densities* of these configurations are inversely as their areas. Now the area of 5*a* (measured on the original prints) is 818 square millimeters, and the area of 5*b* is 992 square millimeters, hence the density of 5*a* is to the density of 5*b* as 992 is to 818. Thus we see how the arrangement of magnets in 5*a* may stand for the molecular structure in the diamond while 5*b* may stand for that in graphite.

Numerous instances exist in chemistry of the same elements combined in the same porportions, yet producing bodies crystallizing in different forms, and having different densities, color, transparency, hardness, etc. As examples of this phenomenon of isomerism we may cite calcium carbonate, which crystallizes in two forms differing in density, viz: as calc spar of a specific gravity of 2·72, and as aragonite of a specific gravity of 2·93. Configuration 6*a* may stand for the molecular structure of calc spar, while 6*b* may stand for that of aragonite. The relative densities of these two configurations are as 208 to 247.

A striking example of isomerism is given in titanic acid, which crystallizes in three distinct forms: as *anatase*, specific gravity 3·82; as *brookite*, specific gravity 4·02; and as *rutile*, specific gravity 4·25. These three isomers may be illustrated by 8*c*, 8*b* and 8*a*, which have respectively the densities of 382, 364 and 360.

It will, of course, be understood that the above paralellisms are given merely as *illustrations* of how our experiments may serve to explain and illustrate the phenomena on the assumption of the atomic hypothesis and on the supposition that the actions which, in the experiments, take place in a *plane*, may similarly take place among repelling and attracting points situate in space of three dimensions.

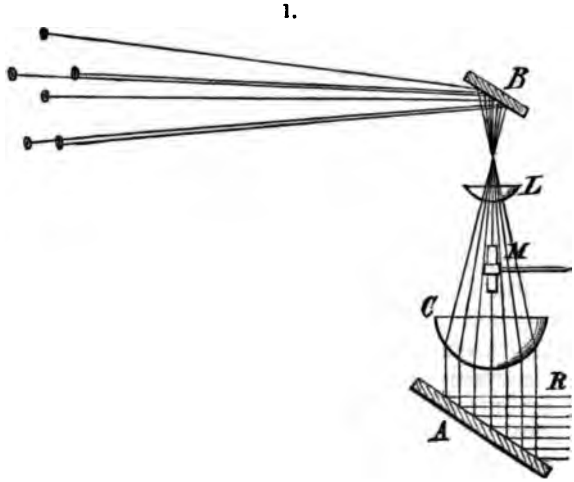
Other forms of the Experiments.—Instead of floating the magnets they may be suspended by fine silk fibers. In this method of experimenting the attractive action of the superposed magnet is replaced by the action of gravity, which draws the mutually repellant needles toward the vertical.

An advantage of this form of the experiment is that the configuration can be transported, and may thus serve in illustration of a moviug molecule as is set forth in the kinetic theory of gases. It is interesting to watch the mutual actions of two or more approaching configurations, and to observe the motions in the exterior and in the contour of a suspended configuration on its impact against a resisting or a yielding surface.

Professor O. N. Rood suggested to me to replace the suspended magnets by gilded pith balls, hung by silk fibers and similarly electrified.

Professor Frederick Guthrie, of London, under date of May 21, writes: "If the corks are made somewhat wider than in your larger needles, the needles move and arrange themselves very quickly if they are turned over and floated on perfectly pure and freshly filtered mercury. Those which reach the edge incline with their corks in the capillary trough."

1.



Method of projecting the magnified images of the experiments on a screen.—To exhibit these experiments before a large audience it is best to use short magnets made as follows: Magnetize rather large sewing needles with their points all of the same polarity, then take each needle between the flat jaws of a pair pliers and with a pair of cutting-pliers snap off the needle close to the jaws of the other pliers. Thus form a series of magnets about $\frac{3}{4}$ inch in length. Run each of these through a thin section of a small cork and then coat both needle and cork with shellac varnish. Float these magnets in a glass tank placed over the condensing lens of a vertical-lantern, or you may even float them directly on the condenser itself if this is

made of an inverted glass shade filled with water. This form of condenser was first used by Dr. R. M. Ferguson, of Edinburgh.

Fig. 1 shows the arrangement of the experiment. The rays of light, R, from a heliostat, or from an oxyhydrogen light, fall on an inclined mirror, A, placed under the water condenser C. The needles float on the surface of the water in this condenser. The rays which have passed through the lens, L, are reflected by the swinging mirror, B, to the distant screen, where they form the images of the floating magnets. The magnet is held over the needles at M, by means of a wire which is wrapped round the magnet to serve as a handle. If a long magnet be used it will work well if its pole is brought over the needles* by inclining it.

These experiments with floating magnets give forcible presentations of the reign of law. It is indeed quite impressive to see order being evolved out of chaos as we hold a magnet over a number of needles, carelessly thrown on water, and witness them approaching and, one after the other, entering into the structure of that geometric figure which conforms to the number of magnets composing it.

ART. XXVIII.—*On the presence of Dark Lines in the Solar Spectrum, which correspond closely to the lines of the Spectrum of Oxygen;* by JOHN CHRISTOPHER DRAPER, M.D., LL.D., Professor of Natural History in the College of the City of New York.

THE measurement of the wave lengths of the dark lines of the solar spectrum obtained by photographs, and the construction of a chart of the same, has for many years occupied my leisure time. As a result of the investigations connected with this work, I have arrived at the belief that oxygen as well as other non-metallic gaseous elements are represented in the solar spectrum by dark lines, in the same manner as metallic substances. The lines in the case of oxygen are however very faint, when compared with those produced by metals in the vaporous state.

The apparatus employed in these investigations may be briefly described as follows: 1st, a spectroscope for photographing the normal solar spectrum. As my purpose was to obtain photographs in which the positions of the lines should be as true as possible, I resorted entirely to the process by reflection, *and at no time did the solar rays pass through glass;*

* The magnetic needles in the experiments may be replaced by pieces of soft iron wire, which will be magnetized by the induction of the superposed magnet.

all error that might arise during refraction was thus avoided. The mirrors of the heliostat were of flat glass silvered, the silver surface being polished served as the reflector. The surface of the concave mirror employed to bring the image of the slit to a focus, was also silvered and polished. Gratings of 4800 and 9600 lines to the English inch, ruled on glass by a machine constructed by myself and my assistant Mr. Sickels, and also an admirable one of 17,280 lines to the inch, for which I am indebted to Mr. Rutherfurd, were used. These were silvered with a thin coating, and the unpolished silver surface employed to give spectra by reflection. With the 4800 line gratings the photographs were in the 1st and 3d orders; with those of 9600 lines in the 3d order, and with 17,280 in the 1st and 2d orders. The accuracy of the gratings was tested with satisfactory results by taking photographs in equivalent orders of spectra on each side of the normal. The photographs for the determination of the wave lengths of the solar spectrum were in sections of eighty to one hundred and fifty wave lengths. The gratings were adjusted to the line of no deviation for the center of each section of the spectrum, as it was photographed.

The wave lengths of the lines of the spectrum were carefully measured on the original photographs, by projecting them upon a scale of wave lengths, each wave length being five millimeters in extent. The scale was drawn upon slips of paper, which had been glued to strips of well-seasoned pine wood cut with the grain. The lantern used for projection was that described in this Journal for April, 1878. The distance of the lantern from the scale, and the consequent magnifying power, was so adjusted as to make the leading lines of the photograph coincide with the same lines of Ångström, drawn in their proper position below the scale as is shown in the diagram given later on. Thus the positions of the lines in each section of one hundred or more wave lengths were all made visible at once, and the errors in Ångström's chart corrected. From 4045 to O in the ultra-violet the leading lines of Cornu were employed. Among the advantages presented by this method of studying and measuring the lines of the spectrum we may mention the opportunity offered for several persons to inspect at the same time the details of the section under examination, and submit them to intelligent discussion. To this we may add the facilities offered for comparing many photographs with each other by marking below the scale the peculiarities of one, and then projecting the others in order upon the marks made. In this way the effects of duration of exposure and manner of development of the image, together with the variation in the size of the slit and focal distance may be investi-

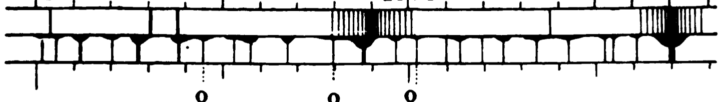
gated, and their action on the details of the picture determined. Pictures may even be placed face to face, one a little above the other, and examined in that position by projection. From the measures thus obtained a chart of the spectrum was constructed, which extended from E in the green to P in the ultra-violet. The values assigned to the wave lengths in this chart are those of Ångström, and it is my purpose to present the positions and characters of certain of these lines in this communication.

The great increase in the number of lines in the chart made from photographs by Mr. Rutherfurd's grating, compared with that of Ångström led me to collect all the measurements of spectrum lines of elements that I could find, for the purpose of determining the character of the newly measured lines. On comparing the lines of the spectra of oxygen, nitrogen and air, as given in Watt's index of spectra, from the researches of Thalén, Huggins and Plücker, I was struck with the number of approximate coincidences between the wave lengths of oxygen lines and those of dark lines in my map. Attempting to make a close comparison of the oxygen with the solar lines I was confronted by the following difficulties, viz: The measurements of Thalén, Huggins and Plücker were given in wave lengths only; fractions being omitted altogether. Error amounting to half a wave length could therefore exist in the position of a line, according as it fell on one side or the other of a figure on the scale expressing a wave length. In the values given to the air lines by Ångström in his chart, this difficulty did not exist; I therefore attempted the use of Ångström's values, employing the work of Huggins and Plücker, to separate as far as possible the oxygen from the nitrogen lines. This operation was, however, quickly discarded; because of the great differences existing between these authorities regarding the wave lengths of a number of oxygen and air lines. To obviate this trouble, I made photographic measurements of the lines of the electric spectrum of oxygen by the method detailed below.

The apparatus employed consisted of a spectroscope with two flint glass prisms of 60°, adjusted to the minimum deviation of D'. Collimator and telescope objectives, achromatics of ten inches focus. This was used to make photographs of the spectra given by the condensed electric spark in oxygen, in air and in nitrogen. When so employed the eye-piece of the telescope was removed, and a camera placed in its stead. The slit was sometimes made as narrow as was possible. The induction coil was one of Ritchie's, giving a ten-inch spark, and having a hammer current-breaker driven by clock work. The battery was three two-gallon bichromate cells, the elements

were large, but just touched the fluid when the battery was in operation. The large mass of fluid in proportion to the immersed area of the elements served to supply a very uniform primary current. The condenser on the secondary current consisted of ten glass plates, each having a tin foil coating of thirty-six square inches. One or more of these plates could be thrown into the circuit as occasion required. By this arrangement a number of photographs of the electric spark between platinum and iron points, in atmospheres of oxygen, and of oxygen and nitrogen were made. The positions of the iron and oxygen lines in these were measured as in the solar photographs, by projection under a suitable magnifying power. The center of each line was the portion from which measures were taken in all cases. The wave lengths of the oxygen lines were then determined by means of a curve, which from $\lambda 3864$ to $\lambda 4414{\cdot}75$ was based on the iron lines of the same spectrum. In all forty-seven iron lines in this extent of the spectrum, or about one to every eleven wave lengths were used. The values assigned to the iron lines were those obtained in my chart of the solar spectrum. By this method of measurement, errors arising from maladjustment of two spectra were avoided. From $\lambda 4414{\cdot}75$ to $\lambda 4705$, the iron lines did not photograph, I was therefore obliged to construct this portion of the curve from the wave lengths of oxygen and air lines already given by various authorities; selecting those values in which they agreed. From 3864 to 4414·75 the results are therefore accurate. From 4414·75 to 4705, though they are approximate, the error if any exists, must be very small. The measurements to fractions of a wave length were obtained by constructing the curve on a scale of sufficient magnitude.

In illustration of the great number of lines presented by my chart of the solar spectrum as compared with that of Ångström, I give a small section extending from 4062 to 4080, within which the oxygen group 4069·80—4072·10—and 4075·50 falls. On the upper part of the diagram the symbols of the elements are placed, to which according to Ångström, corresponding lines are found in the solar spectrum. On the first space below the line is the scale of wave lengths, each wave length being five



millimeters in extent. In the second space the lines of Ångström's chart are given. In the third space the lines measured on the photographs, the vertical portion of each symbol

giving the position, and the horizontal portion the width, and also the darkness on an arbitrary scale of one to ten. The darkest lines encroach most on the vertical portion of the symbol. The value 10 is expressed in the symbol of the Mn Fe line 4063, and the value 1 in that of the line 4068·05. Other features of the lines are shown by the manner in which the upper part of each of these symbols is drawn. Beneath the spectrum lines the scale is repeated, and the position of the oxygen lines indicated. In addition to the lines already mentioned as being in Ångström's chart, lines of the following elements appear in this space, viz: Fe 4063, Pb 4066, Sr 4078, Bi 4080. The correspondence between these values and the wave lengths of the lines in the photographic spectrum is as close as could be expected, seeing that the authorities do not give fractions of wave lengths. The Te line is represented in the spectrum by the Mn Fe line 4063. The Pb line by the spectrum line 4065·7. The Sr line by the line 4077·9, and the Bi line by the line 4079·8.

Inspection of the diagram also shows that while the Mn Fe 4063 lines are coincident in both charts, the Fe line 4071 of Ångström reads 4071·25 in the photographic chart, and the unassigned line 4076·25 of Ångström reads about 4076·20, in my chart the two lines being nearly coincident. In the photographic chart the relations of the lines to each other as regards position are accurately presented, and where these differences occur the positions given in the photographic chart must be correct. The total number of lines in the two charts is also worthy of notice. In the eighteen wave lengths represented in the diagram, Ångström gives six lines, while the photographic chart gives twenty-four. Of Ångström's lines five are assigned to different metals, if we give the line 4066·25 to Pb, and one is unassigned. In the photographic chart these lines also appear, and in addition the lines of Bi and Sr, together with the three oxygen lines. Out of the twenty-four lines ten are assigned to various elements, leaving fourteen to be accounted for; and many of these are moderately strong lines. The oxygen lines represented in the diagram are among the strongest in the electric spectrum of oxygen, yet the equivalent lines in the solar spectrum are faint when compared with the lines of Ca and Fe. This would seem to indicate a low absorbing power in the gaseous non-metallic elements, as compared with the same power in the case of metals in the vaporous state. The existence of a difference like this would explain why it is, that many of the lines in the solar spectrum which represent oxygen have been overlooked. Some of these lines have, however, been observed, Ångström himself giving in his chart a number of lines, not assigned by him nor any

one else to other elements, which are very nearly coincident with the oxygen lines, as determined by the photographic method, as will be seen in the table at the close of this article.

As it is not possible, in the space to which we are limited, to give diagrams of all the portions of the solar spectrum which contain oxygen lines, we present in the following table the positions in that spectrum of all the oxygen lines that were obtained in the photographs of the electric spark in that gas. The first column contains the wave lengths of certain lines in the chart made from photographs of the solar spectrum. The second the wave lengths of the lines of the condensed electric spark in oxygen. The third Plücker's lines of oxygen, which are much more numerous than those of Huggins, which are presented in the fourth column, while the fifth column gives the lines of Ångström's air spectrum, which may be credited to oxygen. The term free in the first column is used to indicate the fact that no element has heretofore been found to give a line within two or three tenths of a wave length of that position. It is therefore free to be assigned as an oxygen line. The chemical symbols on the other lines show that the element indicated has been assigned to that line, and shares it with oxygen. The number of lines of greater wave length than 3961·60, which are free from other elements, and which are assignable to oxygen, is good evidence of its presence in the solar envelopes.

DRAPER. Lines of photographic chart of solar spectrum, with their condition.	DRAPER. Lines of electric spark in oxygen.	PLÜCKER. Lines of oxygen.	HUGGINS. Lines of oxygen.	ÅNGSTRÖM. Lines of spark in air attributed to oxygen.
3864·50^{2} free.	3864·75^{1}			
3882·30^{9} "	3882·30^{3}			
3907·90^{2} "	3908·00^{1}			
3912·25^{3} "	3912·35^{3}			
3919·75^{3} "	3919·50^{3}			
3945·10^{1} "	3945·10^{3}			
3954·60^{3} "	3954·70^{7}			
3961·60^{4} "	3961·60^{3}			
3973·40^{3} "	3973·50^{10}			
3982·75^{1} "	3982·70^{3}			
3995·50^{3} "	3995·50^{5}			
4069·80^{2} "	4069·50^{10}	4069·00^{3}	4069·00^{3}	4069·50
4072·10^{3} "	4071·90^{10}	4072·00^{3}	4073·00^{3}	{ 4071·65 { 4073·65
4075·50^{2} "	4075·45^{10}			4075·50
4084·70^{4} "	4084·80^{5}	4085·00^{4}		
4088·00^{1} "	4087·80^{4}	4086·00^{2}		
4093·20^{1} "	4093·10^{4}	4094·00^{2}		
4104·40^{2} "	4104·50^{6}	4104·00^{2}		4103·00
4111·00^{2} "	4111·10^{4}			
4118·00^{7} Fe.	4118·20^{10}	4117·00^{2}	4117·00^{2}	
4121·20^{3} "	4121·20^{6}			

DRAPER. Lines of photographic chart of solar spectrum, with their condition.	DRAPER. Lines of electric spark in oxygen.	PLÜCKER. Lines of oxygen.	HUGGINS. Lines of oxygen.	ÅNGSTRÖM. Lines of spark in air attributed to oxygen.
4133·00^{3} free.	4132·90^{5}	4126·00^{6}		
4142·90^{7} Fe.	4142·90^{8}	4135·00^{6}		
4145·30^{2} free.	4145·50^{7}	4147·00^{2}	4149·00^{2}	
4152·90^{1} "	4153·00^{8}			
4155·60^{1} "	4155·75^{4}	4158·00^{4}		4155·00
4168·20^{1} S.	4168·40^{4}	4171·00^{2}		
4184·90^{1} free.	4185·00^{8}		4183·00^{5}	4184·50
4189·90^{1} C.	4190·00^{10}	4190·00^{5}		4189·60
4254·30^{1} free.	4254·50^{3}			
4274·80^{4} CrCa.	4275·00^{6}			
4278·10^{3} Pb.	4278·10^{6}			
4303·00^{5} free.	4303·00^{4}			
4316·60^{2} "	4316·50^{8}			
4320·00^{4} TiC.	4319·75^{8}			
4325·10^{10} Fe.	4325·20^{6}	4327·00^{9}		
4328·10^{1} Bi.	4328·20^{4}			
4331·00^{2} free.	4331·20^{4}			
4336·34^{4} SCr.	4336·00^{6}	4334·00^{2}		
4345·15^{2} free.	4345·20^{9}	4341·00^{6}		4345·80
4348·20^{2} "	4348·30^{10}	{ 4347·00^{10} 4348·00^{10}	4347·00	4347·50
4353·00^{2} "	4353·10^{8}			
4365·00^{1} BrCe.	4365·20^{8}		4364·00^{4}	
4369·10^{4} CrFeAs.	4369·20^{4}	4369·00^{4}		
4394·50^{3} free.	4394·50^{4}			
4413·20^{2} "	4413·20^{10}	4414·00^{5}	4414·00^{8}	4414·60
4417·85^{3} "	4418·00^{10}	4418·00^{8}	4416·00^{8}	4418·30
4445·00^{2} "	4445·00^{6}	4443·00^{4}		
4450·00^{2} Mn.	4450·00^{3}	4450·00^{4}		
4463·00^{2} Ce.	4463·00^{8}	4457·00^{4}		
4467·30^{1} Ce?	4467·20^{8}	4468·00^{10}	4467·00^{10}	
4483·80^{1} Fe.	4483·75^{3}	4474·00^{10}		
4572·10^{3} Be.	4572·20^{1}			
4577·75^{6} Ce.	4577·55^{1}			
4582·10^{2} FeCe.	4582·10^{1}			
4589·30^{4} free.	4589·50^{10}		4588·00^{6}	4590·80
4595·40^{3} "	4595·50^{10}	4593·00^{6}	4596·00^{6}	4595·90
4599·80^{3} 4600·15^{4} { Sb. C.P. Cr.	4600·00^{3}	4600·00^{6}		
4629·60^{3} free.	4629·60^{4}	4639·00^{10}		
4640·50^{3} "	4640·20^{10}	4640·00^{10}	4640·00^{6}	4640·25
4648·15^{4} Cr.	4648·15^{10}	4649·00^{8}	4648·00^{8}	
4661·50^{4} free.	4661·50^{8}	4662·00^{7}	4662·00^{7}	
4674·90^{1} CSe?	4675·00^{8}	4675·00^{7}	4677·00^{7}	4674·75
4698·65^{3} free.	4698·50^{10}	4698·00^{7}	4699·00^{7}	4698·00
4704·65^{1} Ba.	4705·00^{10}	4705·00^{7}	4706·00^{7}	4706·50

The table presents what may be called the oxygen region of the spectrum, only a few oxygen lines lying outside of its limits. As this also happens to be the region in which our photographic apparatus and chemicals were most sensitive, we are enabled to present measurements of the majority of the lines of

oxygen. It will be noticed that though the oxygen lines of greater wave length than 4704·65 are wanting, on account of their lack of photographic power, this loss is partly made up by the extension of the measurements into the ultra-violet region, where as yet no exact measurements of oxygen lines have been made that I am aware of.

That there should be no error regarding the nature of the chemical element producing the lines, every precaution was taken to have the oxygen as pure as possible. Photographs of the spark in oxygen, between points of the purest platinum that I could procure, were also made. These were compared with the measured photographs of the spark between an iron and a platinum terminal, and provision was thus made for the detection of any error that might have arisen from impurity in the iron used in the terminal. As these photographs of the spark between platinum terminals in pure oxygen presented all the lines given in the table these lines may be regarded as true oxygen lines. In addition to the oxygen lines given, the following feeble lines were observed, regarding the nature of which I was not quite satisfied, as they did not pass entirely across the spectrum, viz., 4490·30—4505·80—4525·50—4548·75. In the space extending from 4254·30 to 4345·15, many of the oxygen lines are assigned to wave lengths occupied by other elements; for example, Cr, Ca, Sb, Ti, C, Bi. As other lines of these elements did not present themselves in the measured photographs, and as the lines in question were also found in the photographs of the spark between platinum terminals they are to be regarded as true oxygen lines, although they are not given by other authorities. In some of the instances in which elements in addition to oxygen are assigned to a weak line in the solar spectrum, it is very possible that such assignments are in error, because of a lack of fractions in the determinations of the wave lengths of these additional elements. Apparent discrepancies regarding wave lengths in my determinations, and those of the other authorities, are sometimes explained by the fact that a line which is recorded as single in one case, is given as two lines in the other. It is also worthy of remark that in almost every instance in which a line is presented by one authority and omitted by the others, it is to be found in the column containing the photographic determinations, and is an evidence of the superiority of this method of recording the existence and positions of spectrum lines throughout the region over which it can act.

Examination of the table shows that the differences between the wave lengths obtained for the lines of the electric spectrum in oxygen, and the lines of the solar spectrum are very small. Out of the sixty-five lines of the solar spectrum which are as

we have seen assignable to oxygen, in seventeen the coincidences are absolute; in four the difference is only five one-hundredths of a wave length; in twenty-two, ten one-hundredths of a wave length; in four, fifteen one-hundredths of a wave length; in eleven, twenty-one one-hundredths of a wave length, and in the remainder the greatest difference is only thirty-five one-hundredths of a wave length, or about that which Ångström has made in different measurements of the same line in the solar spectrum.

The small figure attached as a power to each wave length of the electric and solar spectra in the table, is a proximate expression of the photographic strength of that particular line in each spectrum, and an examination of these upholds the statement made in a preceding paragraph that the oxygen lines of the solar spectrum are very weak when no other element furnishes a line which falls on the same wave length. Of course photographic must not be compared with visual intensities, for as the one diminishes in the less refrangible regions of the prismatic spectrum the other increases. An example of coincidence in the lines of different elements, and consequent increment in strength, occurs in the line 4118, and probably in the line 4303 also, though it is supposed to be free.

In conclusion, I give a list of certain lines in Ångström's chart which have not as yet been assigned to any element, together with the wave lengths of the same lines in my solar and electric spectra. From this table it will be seen that Ångström himself observed a number of lines, the relations of which to elementary bodies no one has as yet demonstrated, and which I believe represent the oxygen in the solar envelopes.

Table of free lines in Ångström's solar spectrum which may be attributed to oxygen.

Draper's electric spectrum of oxygen.	Draper's solar spectrum.	Ångström's solar spectrum.
4132·90^{6}	4133·00^{3}	4133·20^{2}
4155·75^{4}	4155·60^{1}	4155·80^{2}
4254·50^{8}	4254·30^{1}	4254·55^{3}
4303·00^{4}	4303·00^{5}	4303·00^{2}
4316·50^{8}	4316·60^{2}	4316·50^{2}
4348·30^{10}	4348·20^{2}	4347·95^{1}
4394·50^{4}	4394·50^{3}	4394·45^{2}
4595·50^{10}	4595·40^{3}	4595·20^{2}
4648·15^{10}	4648·15^{4}	4648·75^{4}
4661·50^{8}	4661·50^{4}	4661·70^{2}

The subjects presented in this communication may be briefly summed up as follows:

1. The resort to the process of reflection in producing and

photographing solar spectra, and thereby avoiding certain errors, and the employment of the silvered surface itself of a glass grating.

2. The extension of the measurement of oxygen lines into the ultra-violet region.

3. The measurement in the region of less refrangibility than H, of lines of oxygen not heretofore recorded, and the use of projection as a method of measurement.

4. The establishment of a close relationship in position between certain lines in the solar spectrum and the lines of oxygen; the slight differences that exist being assignable to the experimental difficulties in the way of making accurate measures of the oxygen lines, and falling within the limits of error of experiment.

5. The evolution of the fact that the lines of the solar spectrum which appear to correspond to the lines of oxygen are weak, or faint, and show that that gas possesses a feeble absorbent power when compared with metallic vapors or gases like H, Fe, Ca.

6. The demonstration that in Ångström's chart there are many lines not assignable to any elementary body, and that these lines occupy very closely the positions of certain oxygen lines.

7. The suggestion that the proof of the presence in the solar envelopes of oxygen, and other substances giving faint lines, is a problem not to be solved by the comparison of two spectra of small dispersion. The solar spectrum in certain parts is so crowded with lines presenting all kinds of details, that the only satisfactory way is to make measures of the positions of these lines on a large scale, and as truly as possible, and then compare with these the most accurate measures of oxygen lines that can be made.

ART. XXIX.—*Correction for Vacuum in Chemical Analysis;* by G. F. BECKER.

TURNER, in his atomic weight determinations (1829) was, so far as my information goes, the first to correct the apparent weight of solid bodies in chemical analysis for the air displaced. Berzelius at first accepted this correction but afterward rejected it as insignificant. Erdmann and Marchand adopted the somewhat illogical practice of reducing the body weighed to vacuum while neglecting the correction for the weights. Nor has the practice of living chemists in accurate investigations been less contradictory. Some of them have entirely ignored the buoy-

ancy of the atmosphere while others have laid the greatest stress upon it.

Consistency among chemists in the treatment of this source of error is certainly desirable. The subject is a simple one and the cases in which the correction is of importance are so readily distinguished from those in which it is insignificant as to repay the small amount of thought necessary to discriminate them.

If $w =$ the apparent weight of a body;
$w_{,} =$ the true weight;
$y =$ its specific gravity;
$d =$ the specific gravity of the weights, and
$c =$ the weight of one cubic centimeter of air; then

$$w_{,} = w + \frac{wc}{y} - \frac{wc}{d}.$$

If the necessary correction is x

$$x = w_{,} - w;$$

and if the apparent weight is one gram,

$$x = \frac{c}{y} - \frac{c}{d}.$$

If c and d are regarded as constants, this equation represents an hyperbola referred to axes parallel to its asymptotes.

It will readily be seen that the form of the curve is independent of d, or the material of which the weights are made, this constant simply determining the position of the axis of y, for

$$\begin{cases} x = 0 \\ y = d \end{cases}$$

The curve is plotted (figure, page 269,) for $d = 21{\cdot}5$, the specific gravity of platinum, and $c = 0{\cdot}001225761$, the weight of one cubic centimeter of dry air with the normal carbonic acid contents, at 45° of latitude, the normal pressure, and a temperature of 15°. The abscissæ in the diagram represent the correction for atmospheric displacement necessary per gram in tenths of milligrams. The ordinates represent the corresponding specific gravities. A glance shows that for high specific gravities the correction is small and changes but slowly, while for specific gravities but little in excess of 1, the correction is comparatively large and increases with great rapidity as the specific gravity sinks. This is expressed algebraically by the formula

$$\frac{dy}{dx} = -\frac{y^2}{c},$$

which indicates that the error decreases in proportion to the increase of the *square* of the specific gravity, or that the intervals through which the specific gravity may be regarded as constant decrease as the square of the specific gravity decreases.

Ordinates have been drawn to the curve at equal intervals corresponding, for reasons which will presently appear, to 0·0000667 grams, or two-thirds of one-tenth of a milligram. The abscissa of each of these ordinates represents the mean correction necessary between certain limits of specific gravity. These limits are indicated by the points on the axis of y cut by lines parallel to the axis of x and passing the ends of the arcs the mean abscissa of which is cut by the ordinates. Thus a correction of two-thirds of one-tenth of a milligram per gram corresponds to all the specific gravities between 7·8 and 13·6. The maximum error in this correction will plainly be only one-thirtieth milligram. The figure might evidently be employed to form a table of corrections for vacuum for platinum weights; but while the principle is more readily apprehended geometrically, calculation possesses the advantage in accuracy. An entirely similar figure might be drawn representing the correction for weights of brass or any other substance. The curve would be identical, but the axis of y would cross the curve at $y = d$, for brass $y = 8·5$.

The attempt is rarely made, as is well known, to push the accuracy of chemical analysis even in the most refined investigations beyond one-hundredth of one per cent or one-tenth of a milligram per gram. If the error made in correcting the weighings for the displacement of air is kept within this limit, the requirements of the case will therefore be fully met. Substances the specific gravity of which approximates within certain limits to that of the metal of which the weights are made, consequently need no correction. As may be seen from the figure, if platinum weights are employed, no substance the specific gravity of which exceeds 7·8 requires correction, if one-tenth of a milligram be regarded as an insignificant error. For brass weights the error is less than one-tenth milligram for all known specific gravities above 5·02.

Bodies are usually weighed with both platinum and brass, the integral gram weights being made of the latter metal and the fractions of the former; corrections must therefore commonly be made for each. As the absolute error in neglecting the correction for small fractions of a gram is very slight, while it is as much trouble to ascertain the correction for a milligram as for ten grams, it is convenient to omit small quantities from calculation. Three errors in the correction for vacuum have, then, to be taken into account, viz., that incurred by want of absolute accuracy in correcting for the whole grams weighed with brass weights; a second similarly incurred in weighing parts of a gram with platinum weights, and the error caused by neglecting the correction for small fractions of a gram. The sum of these errors must not exceed one-tenth of a milligram,

a condition which will be fulfilled if none of the three is over one-thirtieth milligram.

The following tables answer these conditions, for all specific gravities above 1, in the fewest possible numbers.

Vacuum Correction.

(Weights of brass) for specific gravity between	Correction per gram. Error $<\frac{1}{30}$ Mg.	(Weights of platinum) for specific gravity between
27·738 and 11·064	−0·000 067 gram.	
11·064 6·904	0·000 000	51·766 and 13·568
6·904 5·019	+0·000 067	13·568 7·807
5·019 3·943	0·000 133	7·807 5·480
3·943 3·247	0·000 200	5·480 4·222
3·247 2·759	0·000 267	4·222 3·433
2·759 2·399	0·000 333	3·433 2·893
2·399 2·122	0·000 400	2·893 2·500
2·122 1·903	0·000 467	2·500 2·201
1·903 1·724	0·000 533	2·201 1·965
1·724 1·576	0·000 600	1·965 1·776
1·576 1·452	0·000 667	1·776 1·619
1·452 1·377	0·000 733	1·619 1·488
1·377 1·254	0·000 800	1·488 1·377
1·254 1·174	0·000 867	1·377 1·281
1·174 1·103	0·000 933	1·281 1·197
1·103 1·041	0·001 000	1·197 1·124
1·041 0·985	0·001 067	1·124 1·059
	0·001 133	1·059 1·002
	0·001 200	1·002 0·950

The fraction which may be neglected without an error of more than one-thirtieth milligram will of course vary with the specific gravity and will in any case be

$$\frac{x}{0{\cdot}0000333},$$

x being the correction. Uniform rules, however, are desirable in the application of such corrections as the one under discussion. It is therefore sufficient to state, that for specific gravities above 1 no quantity less than twenty-five milligrams needs correction, while for specific gravities above 3 nothing less than one decigram requires to be corrected or, in other words, only the first decimal place.

In discussing analyses recorded in the literature of chemistry it is, in a majority of cases, impossible to discover with certainty whether the gram weights were of platinum or brass; though the latter is the rule and an exception to it is apt to be stated. The difference between the corrections per gram for brass and platinum weights is

$$\frac{c}{8{\cdot}5} - \frac{c}{21{\cdot}5} = 0{\cdot}0000872 \text{ gram},$$

and should it be erroneously supposed that the gram weights used were of brass, the total error in the correction would lie between

$$\begin{aligned} &-0{\cdot}000012 \text{ and} \\ &+0{\cdot}000187 \text{ with a mean value of} \\ &+0{\cdot}000087. \end{aligned}$$

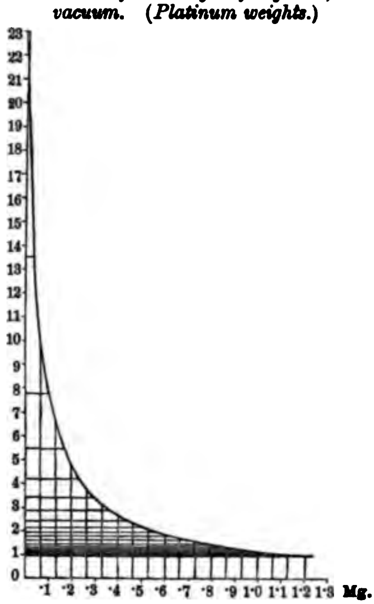
Aluminium is sometimes employed for weights, but, so far as I know, only for the smaller fractions of a gram. The use of aluminium for milligram weights would diminish the error arising from the neglect of the correction for small fractions.

The influence of changes of temperature on the correction for vacuum is readily ascertained. If we call the variation caused by temperature from the correction as calculated for 15°, x_1; then

$$x_1 = C_0\,(t \times 0{\cdot}00366)\left(\frac{1}{y} - \frac{1}{d}\right)$$

C_0 being the weight of one cubic centimeter air at 0°, and t the variation of the temperature from 15°. The value x_1 will be at a maximum for specific gravities above 1 when $y = 1$ and $d = 21{\cdot}5$. Accurate investigations are scarcely likely to be undertaken below 5° or above 25°. But for $t = 10$, x_1 is less than one-twentieth milligram per gram.

Correction of the weight of a gram for vacuum. (Platinum weights.)



A variation of an inch in the height of the barometer would affect the correction still less, and the effects of ordinary elevations and of latitude or the density of the atmosphere are evidently too minute to be taken into consideration in the present state of chemical apparatus.

In conclusion, attention may be drawn to the fact, which appears very plainly in the table, that for the purposes of the reduction of weighings to vacuum, no very accurate determination of the specific gravity is necessary.

Berkeley, California, May, 1878.

ART. XXX.—*On the composition of the new Meteoric Mineral Daubréelite and its frequent, if not universal, occurrence in Meteoric Irons;* by J. LAWRENCE SMITH, Louisville, Ky.

WHEN I first announced the discovery of the mineral daubréelite,* the amount at my disposal was only sufficient for the determination of its specific characteristics. Since then I have made numerous sections of the first iron, which weighed about 250 kilograms, and also sections of another iron of 200 kilograms from the same locality (Cohahuila), and in this last have found the nodules even more abundant than in the first. Of the second iron, I have a section with two polished surfaces of about 900 square centimeters each, which show twenty-five to thirty nodules, varying from three to sixteen millimeters in diameter, at least ten of which are from one to one and a half centimeters in diameter, and all of them exhibit to the eye daubréelite in angular segregations.

The mineral used for my first analysis I obtained by breaking it out from the nodules mixed with troilite and other impurities, depending on the eye to separate the impurities. Since then, I have found that chlorhydric or fluohydric acid will attack the troilite readily and not act on the daubréelite, and thus a method has been adopted by which the mineral is obtained more abundantly and quite pure. The shavings and cuttings procured in making the sections were used (several kilograms of which were at my command); the fragments of iron were separated by a large magnet, and the small particles left behind consisted essentially of troilite and daubréelite; for the former is only feebly magnetic and the latter not at all so. Strong chlorhydric acid is next added to this last portion and gently warmed over a water bath; the troilite is readily attacked; after a time the first acid is poured off, and a fresh portion added, and the digestion continued over a water bath from one to three hours; the residue contains a good deal of light black matter that is easily washed away (this last has not yet been thoroughly examined, but much of it is impalpable daubréelite); the larger black particles are again treated with a little chlorhydric acid, after which the daubréelite is left quite pure and is easily washed, and any foreign particles are readily picked out.

In this form it consists, as already described, of shining black fragments more or less scaly in structure, not altogether unlike fine particles of molybdenite. The fracture is uneven, except in one direction where there appears to be a cleavage. It is

* This Journal, III, xii, 109, August, 1876.

brittle and easily pulverized, the fine particles retaining their brilliancy. It is not magnetic. Before the blowpipe it undergoes but little alteration, losing its luster, but not fusing, and after heating in the reducing flame it is slightly magnetic. With borax it fuses slowly, the smaller particles giving an intense green color to the bead when cold. It is not acted upon in the slightest degree by chlorhydric acid, either cold or hot, but dissolves slowly and completely in nitric acid when heated over a water bath, without, however, any liberation of free sulphur.

Its specific gravity is 5·01. It is needless to give the details of the method of analyses. I will only remark that when a mixture of hydrated oxides of chromium and iron are separated by the addition of bromine to an alkaline solution holding the oxides in suspension, the operation must be repeated two or three times to insure complete conversion of all the chromium oxide into chromic acid, and consequently to separate it totally from the iron.

The following is an average of three analyses giving concordant results within one half per cent of each constituent:

Sulphur	42·69
Chromium	35·91
Iron	20·10
	98·70

A minute quantity, of what appeared to be carbonaceous matter, was mixed with the residual traces of oxides found in the mother-water. It is very evident from the above proportions that this mineral is a sulphide corresponding in atomic constitution to the well-known oxide, chromite ($FeO+\text{Ɛ}rO^3$), daubréelite being $FeS+\text{Ɛ}rS^3$, sulphur replacing the oxygen; the calculated percentage is:

	Calculated.	Found.
Sulphur	44·29	43·26
Chromium	36·33	36·38
Iron	19·38	20·36
	100·00	100·00

	Calculated.	Found.
Sesquisulphide of chromium	69·55	68·00
Sulphide of iron	30·45	29·75

The calculation of the daubréelite is based upon the sulphur found in the analyses (43·26). As yet we do not know of any terrestrial mineral corresponding to this, and it is an interesting fact that we are already enabled to establish so clearly its true composition, and also to obtain good characteristic specimens that will find their way into the principal cabinets of meteorites.

The occurrence of this mineral in so marked a manner in the Butcher meteoric irons of Cohahuila, when it does not show itself in the troilite of other meteoric irons, induced me to investigate this matter carefully, as I now had chemical methods to aid me. Thus far I have examined the troilite from only three meteoric irons, viz., those from Toluca, Mexico; Sevier, Tennessee; and Cranbourne, Australia. In the first two specimens it was found in marked quantities, about 2·5 grams of troilite being employed, but in the case of the Cranbourne, where the quantity did not amount to one gram, the daubréelite was proportionally less than in the other two. The Toluca troilite furnished the largest quantity; the residue from 2·800 grams of it, after thorough treatment with chlorhydric acid, which dissolves nearly the whole of it, was dissolved in part by nitric acid, and on analysis the solution was found to contain chromium and iron representing about sixty milligrams of daubréelite; the mineral obtained from these troilites was of the pulverulent variety.*

There is reason to believe that further research will show the constant presence of daubréelite in meteorites. I am now prosecuting a series of experiments on the mineral segregations in meteoric irons, both those visible and invisible to the naked eye and those only discernible by chemical means, the results of which will tend to a satisfactory solution of this hypothesis.

ART. XXXI.—*On the Artificial Mounds of Northeastern Iowa, and the evidence of the employment of a Unit of Measurement in their erection;* by W. J. McGEE.

WITH very rare exceptions, the artificial mounds of northeastern Iowa and contiguous parts of Wisconsin and Minnesota may be divided into four classes, viz: (1) *tumuli;* (2) conical mounds, similar to the *tumuli* in appearance, but smaller, and bearing no evidence of having been used for inhumation, usually found in rows or series, and in such cases sometimes connected by narrow ridges: (3) embankments; and (4) animal mounds. Isolated mounds are sometimes found, but they occur much more frequently in groups; and where the topography of the country is favorable, many groups may be connected, forming extensive systems. All four classes of mounds often appear in a group, and usually in a system. When exceptions occur, it is most frequently the *tumuli* which are found to be absent. Rarely an embankment or a collection of mounds is so situated

* The undissolved portion after the nitric acid treatment is principally graphite and schreibersite.

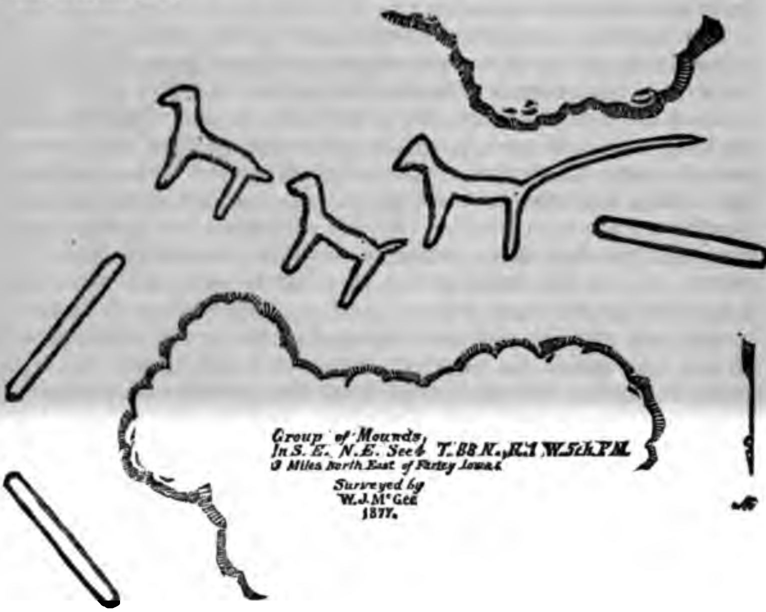
as to lead to the inference that it was designed—partially, at least—for defensive purposes. True fortifications, like those of Ohio and Kentucky, have not, however, been discovered.

Tumuli are never, so far as the experience of the writer extends, regularly and methodically arranged. A few burial mounds occupy prominent spurs and bluffs overlooking water-courses, or other natural elevations. Such mounds usually contain the remains of but one, or at most a few, bodies, and seem to have been used only in exceptional cases. The ordinary grave mounds occur in valleys or on plains, irregularly disposed, and each usually contains the remains of several bodies. Implements, arms, etc., are not always found associated with the human remains in the *tumuli*. In an extensive collection of burial mounds opposite Clayton, Iowa, arrow-heads and spear-points are often found in such positions as to indicate that they were buried within the bodies. A cranium from the same locality has a horizontal indented fracture about two inches above and parallel with the supraciliary ridges, corresponding in shape to the edge of a stone axe. Here, as in other parts of the United States, one of the strata of the material forming the *tumulus* consists of a hard light-colored earth, so indurated as to almost if not quite prevent the percolation of water or the permeation of air. No earth of a like nature can be found in the vicinity of the mounds. Hence it must have been either transported a long distance, or artificially prepared; and the occurrence of a like stratum in the mounds of widely separated localities in which there is the greatest diversity in the superficial geological formations (the stratum being in all cases of different material from any of the natural formations), would seem to indicate that the latter supposition may be correct. The preservation of organic remains within some of the mounds is due to the impermeable nature of this stratum. Where it is not found, all organic matter has been completely decomposed.

The smaller conical mounds (which are, properly speaking, spherical segments) never exhibit a stratified structure, nor do they contain relics of any kind. In height they vary from one to three feet, and in diameter from fifteen to forty feet. They are rarely—perhaps never—isolated, usually occurring in straight or slightly sinuous lines. The object in erecting them is not obvious. Interest attaches to them only from the fact that they are undoubtedly separated by measured distances.

The embankments are straight, about equal in width and height to the small conical mounds, and their length is ordinarily from one hundred to three hundred feet, though they are sometimes much longer. Their dimensions, some of which are given below, are as constant, however, as the distances separating the conical mounds. Except in the very rare instances in

which they may have been designed partly as fortifications, it does not readily appear that they subserved any practical use. This has led many archæologists to infer that they were connected with superstitious observances; but it has occurred to the writer—and the weight attaching to the view may be estimated from a comparison of the dimensions given below—that their purpose was to record the discovery of a linear unit, and, in the absence of a written language, to perpetuate a system of measurement.



The animal mounds are quite similar to those of other localities, and are almost always associated with the last two classes of mounds. In the accompanying figure, three animal mounds and three embankments are represented in their proper relative sizes and positions. Though the variations in the arrangement of different groups are so general that this cannot be called a typical group, it may be taken, nevertheless, as representative of those commonly observed. The animal mounds are fair specimens of their class. All are so disposed around the head of a ravine as to admit of the idea that they may have been partially designed to protect an encampment or domicile. A mile to the westward, on the same natural elevation, is a single animal mound of large dimensions; and two miles to the eastward, at the termination of the same ridge, are two embankments, each forty yards in length.

The last three classes of mounds are commonly found on ridges separating water-courses, though they sometimes occur on "benches" and "bottoms." Few of the prominent ridges on either shore of the Mississippi from Dubuque to the Minnesota line are free from them. Excavations from which the earth forming any of the mounds may have been taken, have never been found in this region, so far as known to the writer. Mounds sometimes appear on rocky spurs, whither it would seem their constituent materials must have been transported from considerable distances.

Having had occasion to survey many groups and systems of mounds, recording all measurements for the purpose of plotting the works, the writer has been struck by the constancy of certain dimensions and the harmony observable in all, whatever the variation, indicating to a certainty the use of a unit of linear measurement in their erection—a peculiarity which seems to have been hitherto overlooked, so far as the mounds of the Northwest are concerned. The use of such a unit being certain, it is possible, if not probable, that the consideration of the results of many measurements of mounds may enable us to determine the value of the unit. The most serious difficulty in the way of such a determination lies in the fact that it is almost impossible to ascertain the precise boundaries of the embankments or the exact centers of the conical mounds—and it is from these points that measurements must be made.

In order to exhibit the harmony in the dimensions of the mounds, and to throw as much light as possible on the question of the value of the Mound-builders' linear unit, a number of measurements are here given. Most of them being made only for the purpose of plotting the works, they are not strictly accurate—i. e., in inches and fractions of inches—though probably as satisfactory as any measurements can be, owing to the impossibility just mentioned of making any measurements correspond precisely with those originally employed. Distances are given in yards, as it is found that fractions rarely occur when this unit is used.

One of the most extensive systems of mounds in northeastern Iowa occupies the ridge or divide separating the Mississippi and Turkey Rivers. The width of the ridge nowhere exceeds a mile, and it is usually quite narrow. It rises from two hundred to three hundred feet above the level of the rivers, and terminates just above their junction in a perpendicular ledge of Galena limestone one hundred and fifty feet high, twenty to forty feet wide, and over a thousand feet long. The system of mounds extends for six miles in a northwesterly direction from this point, and consists of conical mounds, embankments, animal mounds, and perhaps *tumuli*. Beginning at the end of the

system remote from the junction of the rivers, the distances separating the mounds and the lengths of the embankments, are as follows:—

Mounds.	Spaces.
Conical,	50 yds.
"	25 "
"	25 "
"	25 "
"	25 "
"	25 "
"	25 "
"	*break.*
Embankment, 37 yards,	*break.*
Conical,	75 yds.
"	12 "
"	12 "
"	25 "
"	30 "
Composite (four conical mounds connected), 35 yards,	20 "
Conical,	15 yds.
"	15 "
Composite (two conical mounds connected by emb.), 35 yds.,	30 "
Embankment, 40 yards,	15 "
" 40 "	20 "
Conical,	20 "
"	20 "
"	20 "
"	20 "
Embankment, 100 yards,	*break.*
Conical,	25 yds.
"	15 "
Embankment, 44 yards,	*break.*
Conical,	40 yds.
"	38 "
"	20 "
"	40 "
"	154 "
"	28 "
"	18 "
"	18 "
"	18 "
"	18 "
"	20 "
"	20 "
"	*break.*
"	40 yds.

Mounds.	Spaces.
Embankment, 85 yards,	73 yds.
" 40 "	*break.*
Conical,	17 yds.
"	17 "
"	17 "
"	17 "
"	23 "
"	*break.*
Embankment, 44 yards,	60 yds.
" 35 "	15 "
" 35 "	15 "
" 75 "	65 "
" 100 "	*break.*
" 50 "	*break.*
" 40 "	60 yds.
" 35 "	12 "
" 58 "	20 "
" 32 "	*break.*
Conical,	44 "
"	40 "
"	28 "
"	28 "
"	33 "
"	33 "
"	31 "
"	35 "
"	50 "
"	32 "
"	*break.*
"	28 "
"	23 "
"	*break.*
"	17 "
Embankment, 35 yards,	40 "
Conical,	50 "
"	25 "
"	60 "
Embankment, 40 yards,	*break.*
" 40 "	15 yds.
" 37 "	15 "
" 33 "	20 "
" 50 "	55 "
Conical,	20 "
Embankment, 44 yards,	30 "

A group extending along a spur:—

Mounds.	Spaces.
Conical,	23 yds.
"	23 "
"	23 "
"	17 "
"	17 "
"	17 "
"	17 "

Mounds.	Spaces.
Conical,	23 yds.
"	17 "
"	17 "
"	17 "
"	17 "
"	30 "

Again in main system:—

Mounds.	Spaces.	Mounds.	Spaces.
Embankment, 50 yards, ...	20 yds.	Tail of animal (dog?) mound, whole length, 65 yards, ...	*break.*
" 33 "	12 "	"Alligator" mound, 49 yards,	14 yds.
" 50 "	15 "	Composite, three conical, connected by two embankments, each 37 yards.	36 "
" 44 "	12 "	Embankment, 33 yards, ...	*break.*
Conical, ...	20 "	" 33 "	*break.*
"	30 "	Conical, ...	19 yds.
"	15 "	"	19 "
Embankment, 33 yards, ...	50 "	"	19 "
Conical, ...	*break.*	"	55 "
"	23 yds.	"	44 "
"	23 "	Embankment, 50 yards.	
"	14 "		
"	14 "		
"	8 "		

A group in the western part of Dubuque county, Iowa:—

Mounds.	Spaces.	Mounds.	Spaces.
Embankment, 55 yards, ...	75 yds.	Embankment, 40 yards, ...	23 yds.
" 85 "	12 "	" 40 "	26 "
" 63 "	16 "	" 40 "	45 "
" 60 "	10 "	" 325 "	
" 40 "	12 "		

In the group in the figure, the measurements, beginning at the west (right), are:—

Mounds.	Spaces.
Embankment, 40 yards, ...	18 yards.
Animal (body and head) 32 yards, ...	18 " (to tail).
" " " 30 "	5 " "
" " " 30 " (from fore-leg), .	23 "
Embankment, 38 yards, ...	38 "
" 36 "	

On comparing the dimensions of the fifty mounds we find one of each of the following lengths, viz: 36, 38, 49, 55, 58, 60, 63, 65, 75 and 325 yards (some of these, too, are of an anomalous character). Of 30, 32, 85 and 100 yards respectively, there are two each; of 37 and 44 yards, three each; of 33, 35 and 50 yards, five each; and of 40 yards in length, eleven mounds. In all there are twenty different dimensions. Comparing the spaces separating the mounds, we find that there are of 5, 8, 10, 16, 26, 31, 32, 35, 36, 38, 45, 65, 73 and 154 yards respectively, one each; of 33, 44, 55 and 75 yards, two each; of 14, 19 and 60 yards, three each; of 28 and 50 yards, four each; of 30 and 40 yards, five each; of 12 and 18 yards, seven each; nine spaces of 25 yards, ten each of 15 and 23 yards, thirteen of 17, and fourteen of 20 yards. In the one hundred and nineteen spaces, there are but thirty-two different dimensions.

But in many cases the lengths of the mounds are equal to the spaces between the mounds. Comparing both spaces and mounds, therefore, we have one hundred and sixty-nine dimensions of thirty-eight different values, as follow: of 5, 8, 10, 16,

26, 31, 45, 49, 58, 63, 73, 154 and 325 yards respectively, one each; of 36, 38, 65, 85 and 100 yards, two each; of 14, 19, 32, 37 and 75 yards, three each; of 28 and 60 yards, four each; five dimensions of 44 yards each, and six of 35; of 12, 18, 30 and 33 yards, seven each; of 25 and 50 yards, nine each; of 15 and 23 yards, ten each; thirteen dimensions of 17 yards, fourteen of 20 yards, and sixteen of 40 yards each. Obviously such coincidences could not occur casually. Though the number of measurements here recorded is too small to base any far-reaching conclusions upon, they will afford a safe foundation for investigations, as they have been selected at random from many localities in different counties. A comparison of a larger number of measurements would only tend to reduce the number of values in proportion to the dimensions; though there would ultimately remain, of course, a considerable number of mounds unique in size as well as other characteristics.

These dimensions seem to indicate that the unit employed either was simply, or had grown out of, the pace, or yard. The possession of such a unit would not point to a race of very high intellectual culture, though to one widely removed from the lowest savages.

The northern limit of the mounds of definite dimensions is not certainly known. The writer has sought vainly for evidence of the use of measurements in the most northerly of the mounds. His own examinations so far extend only to latitude 43° 30′ N., and there the mounds are of constant or related dimensions. The most northerly of the measured mounds are undoubtedly within Minnesota.

If we assume a slow southerly migration to have taken place in the Mound-builders, it will explain the evident increase in geometrical knowledge attested by the various works found in passing across the United States from north to south. Here we have measurements of simple lines, but not of angles or areas. In Ohio, angles were correctly measured, as we find from the squares being accurate squares and the circles perfect circles;* and areas were measured, as attested by adjoining squares and circles being equal or very nearly equal in area,† though there is no satisfactory evidence that the cardinal points were then known;‡ and in the lower Mississippi region the cardinal points were known.§ The gradual modification in the various arms and implements, and the striking improvements in pottery, together with many other important considerations, lend support to this view.

Farley, Iowa, August 1, 1878.

* Squier and Davis, "Ancient Monuments of the Mississippi Valley," pp. 9, 56.

† Ibid., plates XVII and XXV; also the whole chapter descriptive of "Sacred Enclosures."

‡ Ibid., p. 66.

§ Ibid., pp. 116, 117.

ART. XXXII. — *Observations upon the Solar Eclipse of July* 29, 1878, *by the Princeton Eclipse Expedition*; by Professor C. A. YOUNG.

THE Princeton expedition to the Rocky Mountains to observe the recent eclipse, was organized early in the year, and its expenses were mainly provided for by a liberal appropriation made for the purpose by the trustees of the estate of the late John C. Green. I have said, mainly, because we are also greatly indebted to the kindness of the managers of the Pennsylvania, the Chicago and Alton, and Kansas Pacific Railroads, and to the American Express Company, for the free transportation of persons and instruments, to the authorities of the State of Colorado for the loan of camp equipage, and to the Western Union Telegraph Company for various courtesies. We are also under obligations to Mr. Edison, to Rutgers and Dartmouth Colleges, and to the observatory of Harvard College for the gift or loan of apparatus.

Our principal object was to investigate the spectrum of the corona and chromosphere — not only the visible portion, but also, and especially, the invisible portions below the red and above the violet. It was hoped that some new lines might be discovered in these portions by the help of the thermopile, photography or fluorescence, but in this respect, as will be seen, our hopes were not fulfilled. Indeed we were well aware from the outset that the chances were considerably against us, and that it was quite likely, as it turned out, that the corona would sympathize with the present general apathy of the solar surface to an extent which would make the bright lines of the corona spectrum unusually faint and difficult of detection.

Our party, under the charge of Professor Brackett and myself, consisted of ten persons when we left Princeton on July 1st. We were joined in Missouri by another, and after we went into camp at Denver by still another, making up our proper party to twelve persons. Mr. Ranyard of the Royal Astronomical Society was also with us as our guest, and observed from our camp, and on the day of the eclipse we were assisted by several volunteers who came out from the city for the occasion.

Arriving in Denver on July 5th, we went into camp on the 7th in a grove on the bank of Cherry Creek about two and a half miles southeast of the city. Our position was determined by a triangulation made by Messrs. Libbey and McNeill, connecting us with several well determined points in the city.

Assuming for the High School house in Denver, lat. 39° 45′

00·6″, long. 1^h 51^m $45{\cdot}2^m$ west of Washington, according to the data kindly furnished by the Coast Survey, the position of the pier of our equatorial was, lat. 39° 43′ 27″, long. 1^h 51^m $40^s{\cdot}4$ west of Washington. The other instruments were all within 150 feet of this. Our equipment was as follows: For time, we had a sidereal box chronometer, with electric break circuit, by Parkinson & Frodsham, No. 4121; also a mean time pocket chronometer by the same makers, No. 5450. The rates of both were small and very regular. Their errors were determined every fair day by altitudes of the sun measured with a Pistor & Martin's prismatic sextant and artificial horizon. It was only rarely that we could get equal altitudes in morning and afternoon, as the afternoons were usually cloudy even when the mornings were fine. For chronographs we had two Morse registers of the European pattern.

For the ordinary ocular observations we had: (1) A four-inch telescope by Clark—the object glass of the meridian circle of the Princeton Observatory—temporarily mounted in a rough tube upon a very rude altitude and azimuth stand. It was fitted with a Herschel solar eyepiece and power of about fifty. Professor Brackett used this in observing the first and last contacts. (2) A four-inch dialytic by the late Mr. Sage of Orange, N. J., equatorially mounted. This instrument was kindly loaned by Mrs. Sage at the request of Professor C. G. Rockwood, who observed with it the first and last contacts, assisted by Mr. J. C. Grant. (3) A telescope of two and three-fourths inches aperture, the object glass, by Clark, belonging to the Princeton transit instrument, mounted upon a rough equatorial stand, and provided with a screen for observing the projected image of the sun. (4) A comet-seeker by Fitz, six inches aperture and about forty-six inches focus, with a curious arrangement of two eyepieces: power 19·5. This was mounted upon a tripod with altitude and azimuth motion. It was used by Mr. Malcolm McNeill during totality in sweeping for intra-mercurial planets, but without success.

After totality the large equatorial of the Princeton Observatory, having nine and a half inches aperture and twelve feet focus, was used by myself with the Merz polarizing eyepiece and power of 250, in observing the cusps and the moment of last contact.

For observing the visual spectrum of the corona four instruments were provided. (1.) The large equatorial with clockwork just mentioned. This was fitted with a single-prism spectroscope, and fluorescent eyepiece, having a film of solution of Æsculin about 1mm. thick. With this the dark lines of the ordinary solar spectrum could be easily seen as far as O, and with precautions I could see even farther. The eyepiece could be set axially as well as obliquely. I used this instru-

ment myself during totality. (2.) The finder of the equatorial is a fine telescope of three inches aperture. To this was fitted a spectroscope with a diffraction grating on silvered glass by Rutherfurd, 17,280 lines to the inch. With this I observed the first contact, and the behavior of the spectrum up to totality. During totality it was not used. I was assisted during the eclipse by my son, Mr. C. I. Young, who pointed the telescope and made my records.

(3.) A single-prism integrating spectroscope mounted equatorially, with an opera glass in front of the slit as a condenser. The collimator and telescope had each an aperture of two and a half inches, and a focal length of twenty-six and a half. The prism, kindly loaned for the occasion by Professor Emerson of Dartmouth College, had a refracting angle of forty-five degrees, and faces two and a quarter by two and a half inches. It was mounted, not at the angle of minimum deviation, but in such a way that by moving a lever it could be slightly rotated so as to throw the spectrum across the field of view. The whole was mounted equatorially, but without clockwork, and was committed to Mr. C. D. Bennett. (4.) An integrating spectro scope of high dispersion by Grubb. This had telescope and collimator of one inch aperture and twelve inches focus, with a train of dense sixty-degree prisms, varying in number at pleasure from ten to four—six were used during totality—it was fitted with an opera-glass condenser like the preceding. The dispersive power was too great, and nothing at all was seen with it by Mr. H. S. Smith who had it in charge.

(5.) For the observation of the spectrum-images of the corona, a slitless spectroscope of peculiar arrangement was employed, constructed specially for the purpose by Clark & Sons. Two small telescopes, precisely similar, each of two inch aperture and fourteen inch focus, with a magnifying power of ten and a half were placed parallel to each other upon a board, and in front of their object glasses were secured two thirty-degree prisms each four and a half inches long by two and a quarter wide. One face of the anterior prism was set so as to be perpendicular to the incident light, and one face of the other prism was perpendicular to the optical axes of the telescopes. The whole affair was mounted equatorially upon a post by Professor Rockwood (who had charge of the instrument) in a very ingenious manner, so that the plane of dispersion could be altered at pleasure. The three inch telescope before mentioned was attached to the same stand and arranged for polarization observations during the totality, but Professor Rockwood did not get time to use it. During the totality, Professor Brackett also examined the coronal images as seen by looking with the naked eye through a direct-vision prism of considerable dispersion.

Our photographic attack upon the corona spectrum employed four instruments. (1.) A spectroscopic camera with diffraction grating of 8640 lines to the inch, the ruled surface two and one-fourth by one and three fourth inches. The collimator had an achromatic lens of three inches aperture and about forty inches focus; the slit was about three-fourths of an inch long, and so arranged that one-half of it could be uncovered at a time, for the purpose of securing the dark lines of the solar spectrum as reference marks by a short exposure of one-half the slit after totality, the other half having been exposed during the totality. The image was formed upon the plate by a quartz lens two inches diameter and twenty inches focus. The light was concentrated upon the slit by an opera-glass condenser with quartz lenses. The whole was equatorially mounted upon a post. With sunlight this instrument gave strong and beautifully defined impressions of the spectrum from F to O with exposures of between one-fourth and one-half a second; but the plate exposed through the whole of the totality showed no trace of action, to the great disappointment of Mr. W. Libbey, Jr., who had charge of the instrument and undoubtedly got from it all it would do.

(2.) A prismatic camera, consisting of a slit, a prism and a single quartz lens of ten inches focus. This instrument also had an opera-glass condenser, but of glass lenses, and was mounted equatorially upon a post. The rays from the slit were not rendered parallel before passing the prism, the lens being between the prism and sensitive plate. The slit of this instrument was arranged so that exposures of different lengths could be given to different adjacent portions of the plate. It gave impressions even more quickly than the preceding in full sunlight, but like it, failed to give any result during totality, notwithstanding the skillful management of Mr. W. W. McDonald, to whom it was intrusted.

(3) and (4) were slitless spectroscopes mounted together upon an equatorial stand kindly loaned to us by Professor Pickering, of the Harvard College Observatory. Professor Brackett, with great skill and ingenuity, attached to this an excellent clockwork compiled for the occasion mainly from the movement of the chronograph of the Princeton observatory. In one of the instruments the dispersion was effected by a speculum-metal grating of 17280 lines to the inch, with a ruled surface two and one-fourth by one and three-fourth inches. In the other a sixty-degree prism of white flint was used. The image-forming lens in each case was an achromatic of about two and one-half inches aperture and twenty-four inches focus. About eight minutes before totality, the diffraction instrument, with a five-second exposure gave a fine spectrum, but neither

of them succeeded during totality. Professor Brackett, assisted by his wife, took this double instrument as his special charge, though he besides had the entire management and oversight of all the photographic work; and not only so, but nearly everything that was ingenious in contrivance and skillful in execution was his also.

For photographing the corona, we had a six-inch telescope by Clark, with an object glass specially corrected for the actinic rays, loaned us by Professor Pickering. This was mounted upon an equatorial stand with clockwork, lent to us by Rutgers College. Mr. G. H. Calley was put in charge of this instrument and obtained with it three fine pictures of the corona with exposures of ten, fifteen and twenty-five seconds respectively. A plate which was to have had forty seconds exposure was unfortunately lost.

Only one instrument remains to be mentioned, that with which we attempted to explore the infra-red portion of the spectrum. It was a spectroscope, with thermoscopic apparatus substituted for the retina. A tube about five feet long carried at the upper end a slit two inches long taken from a Duboscq electric lantern. At the lower end of the tube was mounted a large spectrum-metal diffraction grating 5760 lines to the inch, in such a manner that it could be slightly turned by moving a long lever. In front of the grating was fixed a two-inch quartz lens, at the end of a bifurcated tube, suitably diaphragmed, and carrying at the other end a delicate line thermopile and a tasimeter. The whole apparatus was attached to a board equatorially mounted. In a large box close at hand was placed a delicate differential reflecting galvanometer, constructed by Professor Brackett specially for the purpose—as, indeed, was also the thermopile—both galvanometer and thermopile distinctly superior to anything we could otherwise obtain.

We had relied mainly upon the tasimeter, which Mr. Edison himself constructed, and gave to us, with a wholehearted generosity which deserves and has our sincerest thanks. We received the instrument, however, only the day before leaving home, and when we came to experiment in the field we found it quite impossible to do anything with it without completely remodelling the whole apparatus, which there was no time to do. Whenever the direction of the instrument was changed to keep the collimeter pointed to the sun, the whole adjustment of the tasimeter was destroyed. It needs to stand unmoved upon a firm foundation, while the rays under investigation are brought to it by reflection. Under the circumstances we were, therefore, obliged to rely wholly upon the thermopile.

Mr. A. D. Anderson managed the lever which moved the

grating and observed the galvanometer, while Mr. Taylor, of Denver, who joined us for the day, directed the collimator. Doubtful indications were obtained of a heat line having a wave length of about 8540 of Ångström's scale.

Of the instruments described the large equatorial was mounted under a sort of railroad car, which could be run off on a track so as to uncover the telescope when wanted. The photographic telescope and Professor Brackett's instrument were in a separate house, which also contained the photographic dark room, the telegraphic apparatus and chronometers. The other instruments were so arranged that they could be easily dismounted and brought under shelter when necessary.

The weather was very unsatisfactory for most of the time between our arrival upon the ground and the eclipse, especially for the ten days immediately preceding. The mornings were very generally clear, but by eleven o'clock the sky would be more or less completely overcast with heavy cumuli rolling down from the mountains, and in the afternoon there would be thunderstorms, sometimes of great violence. But the day of the eclipse was almost perfect; there were no clouds except one or two little fleecy things which kept out of our way, and a heavy bank over Long's peak, just where it was wanted to bring out the effects of the advancing shadow.

Observations of Contacts, etc.

The first contact was noted by Professor Brackett with the four-inch telescope at $2^h\ 19^m\ 43^s{\cdot}3$, local time. By myself, with the spectroscope attached to the three-inch finder of the equatorial, the moon was first certainly made out encroaching upon the chromosphere at $2^h\ 19^m\ 33^s$, and contact with the limb was noted at $2^h\ 19^m\ 46^s{\cdot}0$, both local time.

Professor Rockwood with the four-inch dialytic, power 100, noted the first contact as having occurred—a *past* event—at $2^h\ 20^m\ 07^s{\cdot}8$, local time. He remarks, "I was conscious that this was too late by certainly several seconds." The instrument was not provided with a convenient means of marking the place of contact, which occurred at a point not exactly where it was expected. No observations were made of second and third contact. The last contact was noted by Professor Brackett at $4^h\ 35^m\ 10^s{\cdot}7$; by Professor Rockwood at $4^h\ 34^m\ 53^s{\cdot}8$; by myself, with the nine and a half-inch telescope, full aperture, polarizing eye-piece and power of 250, at $4^h\ 35^m\ 14^s{\cdot}5$—a very satisfactory observation.

It will be remembered that the error of the standard chronometer was determined by sextant observations upon the sun, and the local time is therefore uncertain to the extent of at least 1·5 seconds from this cause.

During the progress of the eclipse, before totality, Professor Rockwood looked carefully for any such phenomena as brushes of light at the cusps, and after totality both Professor Brackett and myself joined him in the examination with our instruments, but nothing abnormal was seen by either of us. With the large equatorial the definition was most of the time very fine indeed.

Fringes.—Mr. McNeill, who was in charge of the comet-seeker, observed them hurriedly as totality came on. He says: "On the approach of totality I observed a series of shadows parallel to each other, somewhere about five inches wide and three feet apart. They extended from southwest to northeast, and moved in a direction perpendicular to this toward the southeast, at a rate of some eight or ten miles an hour."

Mr. Smith also saw them and gives the following account of them: "During the last thirty seconds of totality, when looking to see if my instrument was properly pointed, I saw a series of black shadowy bands moving in a direction contrary to the moon's motion. They were about three inches in breadth and about two feet apart, and their length was at right angles to their line of motion. After totality I measured approximately the direction of their length and found it to be about north thirty east. In the limited field of view that I had these lines appeared to be straight, but not even, looking as if made up of crescents having their points overlapping. I did not look at them for more than a few seconds." Mr. Smith also informs me verbally that the velocity of movement rather exceeded a very fast walk—say from five to six miles per hour—also that he estimated the dimensions by measuring, the next morning, upon the ground, the distance between objects over which the fringes passed simultaneously. The fact that the movement as he saw it was just opposite to Mr. McNeill's impression, is of course noticeable. Perhaps the explanation may be connected with the fact that one observed at the beginning, and the other at the end of totality. Mr. Pickering, however, who though not of our party observed in our enclosure, described the movement as *vibratory* rather than progressive.

Spectroscopic Observations.

Analyzing spectroscope.—I observed the first contact with the diffraction spectroscope attached to the finder, and after that, during the progress of the eclipse, I gave a most careful scrutiny to all the principal dark lines of the spectrum to ascertain whether there was any absorptive action to be detected at the moon's limb. I tried spectra of various orders, so as to give both extremely low and extremely high disper-

sion, but in all cases and with all the lines found only one emphatic negative result.

About ten minutes before totality the number of chromosphere bright lines, visible in this instrument began to increase. 1474, the *b.s* and others in that part of the spectrum began to be conspicuous, and I turned my attention to the single prism instrument with the fluorescent eyepiece. At this time I found I could see the dark lines quite to 0, and rather better than before the eclipse began. I adjusted the slit tangent to the expected point of contact, and brought to the center of the field the portion of the spectrum between D and E, the field extending from about C on one side to above F on the other. At the moment when totality began, the field was filled with bright lines, which came into brightness, not instantaneously, but brightening perhaps half a second, remained steady nearly a second and then faded out and disappeared, not all together but successively, most of them being lost within two seconds of their first appearance, while some lasted three or even four seconds. After this there remained bright in the field C, D_3, 1474 and F. No lines could be seen between D_3 and 1474. I immediately began to work the tangent screw to bring down the ultra violet into the field, and while I was doing so, my son accidentally let the image of the corona get off from the slit, and as it moved off I noticed the persistency of 1474 still visible in the edge of the field to a distance of at least ten minutes from the limb. F disappeared at a distance not much more than five minutes. There was a little difficulty in repointing the instrument, as the *slit* could not be easily seen, though the image of the corona was fairly bright. While my son was bringing things to place I looked at the eclipse for perhaps ten seconds and saw the *polar* streamers of the corona, but did not notice the equatorial ones and was surprised at not seeing them. I also noticed a quivering of the air along the telescope tube. The corona seemed to me much less brilliant, but not less extensive than in 1869 and 1870. Applying my eye again to the eyepiece I worked up as rapidly as possible into the ultra violet, and tried every device I could think of to find lines there, but without success, though there was a faint continuous spectrum. In a few seconds the totality ended, its termination being heralded by the reversal of the two H (calcium) lines as the image of the prominences and chromosphere fell upon the slit. I had never been able to see this before since my first observations of the same thing in 1872, at Sherman. I saw no other lines reverse at close of totality.

The observations were greatly facilitated by the count of seconds which was kept up with perfect steadiness and accuracy

by Mr. W. H. Pierce, of Denver, who kindly volunteered to assist us in this way. Starting his stop watch at a signal given by Professor Rockwood, he beat once in two seconds with a small hammer upon an anvil so as to be distinctly heard through the whole ground, and called out every tenth second. Thus every observer knew precisely how much time remained at his disposal. With the single prism integrating spectroscope, Mr. Bennet saw at the beginning of totality, for three or four seconds F and 1474, and these only—he could not see C—why, I cannot imagine, but with nearly the same instrument Mr. Abbay had a similar experience in Spain in 1870. During totality the continuous spectrum was too faint to show the spider lines. Four seconds before the end of totality 1474 "shot out" again, followed by the bluish green line, which was seen to change into the dark line F. F was much brighter and broader than 1474. No dark lines could be seen, nor indeed lines of any kind except the two named, and that only for a few seconds at beginning and end of totality.

With the six-prism Grubb spectroscope, Mr. Smith could see absolutely nothing.

Slitless spectroscopes.—Professor Brackett reports his observation as follows: "About thirty-five seconds of the totality had passed when I had put my plates in their places and waited for quiescence and exposed them. My eye of course was in its most sensitive condition as I had just left the dark room. The first thing I did, therefore, was to take a large direct vision prism having neither slit nor telescope, and look for rings. I saw none but did see clearly the following that were very clear and distinct. A line in the red, one in the yellow, one in the green and a fourth in the violet [? blue]. All these lines were clear and sharp as long as I continued to look, perhaps ten or fifteen seconds. They were not to be seen at any considerable distance from the moon, and only along its eastern limb, extending over an arc of about 120°." Of course the lines seen were C, D_3, 1474, and F. Professor Rockwood used the binocular instrument described previously. I give his interesting report in his own words and in full. "As totality approached I went to the binocular and by help of a dark glass watched the spectrum of the sun's crescent seen there, having placed the instrument so that the plane of dispersion of the prisms was perpendicular to the line of the cusps. I had previously focussed the telescopes carefully upon the distant mountains, and during totality this focus was not changed. Some considerable time (probably eight or ten minutes) before totality I was able to see the prominent dark Fraunhofer lines. The number of these increased until just before totality, when the crescent was very narrow. I had a bright continuous spectrum some ten minutes

wide, showing, as it seemed to me, the full solar spectrum with all its dark lines as when a slit is used. These lines were so sharp and distinct that I counted and noted five distinct dark lines between the two H's. At this time, and before, I noted also a bright band in the neighborhood of *h*, which may have been due to Hδ or may have been owing to the absorption of the dark glass I was using, a London smoke. When the light was sufficiently reduced, some fifteen seconds or so before totality, I discarded the dark glass, and moved my eye so as to see only the violet end of the spectrum and then followed it down toward the red, as fast as the fading brightness of the light would permit, until I was able to see the whole spectrum about covering the field of my instrument.

"At the commencement of totality I was thus watching the dark lines, when suddenly the sun's disk was entirely covered and I saw a number of *bright* crescents crossing the still visible continuous spectrum. They projected on both sides beyond the continuous spectrum, being certainly fifteen minutes and perhaps twenty minutes long. They showed upon them several prominences. I noted two small ones near the south limit and three larger near the north limb, the most northern one having a hook form. I failed to get note of *what* lines these crescents belonged to, but immediately afterward I put down from memory these—near B(?), C, D_3, 1474, F, (Hγ). On the appearance of these bright crescents I gave the word to Mr. Pierce to begin counting. I continued to watch them and the continuous spectrum, looking for the latter to break up into rings. The moon gradually covered the crescents, leaving still the tops of the prominences visible as bright points seen in several colors. When these points were almost covered I called "stop" to Mr. Pierce, and found afterward from his watch that two minutes twenty-eight and a quarter seconds had elapsed since I first saw them. But by this time the prominences on the western limb had begun to be uncovered, and in a few seconds the northern ones had joined in a long sierra, and then I had a new set of crescents in view. Of these I noted the following lines: near B, C, D_3, 1474, F, Hγ, H_1, H_2. These all showed clear and bright, and in addition there were four or five fainter ones between F and Hγ which I could not locate exactly. Those named did not differ much in brightness, and I *did not notice* but that the forms of the prominences were the same in all, still I cannot be positive about that.

"The spectrum of the corona during all of totality was continuous and tolerably bright. I saw no dark lines crossing it, but did not look particularly for them and should not expect to see them with my instrument. It did *not* show any *bright*

rings. I looked most carefully for them, expecting to see them. Once about the middle of totality I thought I saw traces of a ring about where 1474 ought to be, but a second look did not confirm the impression. The continuous spectrum seen during totality was somewhat wider than the moon's disk, but I cannot say how much, nor can I tell just when it assumed the greater width. Before totality it was quite narrow and the bright crescents projected on both sides beyond it. But I remember that in looking for the rings I expected them to be seen *upon* this spectrum and not to project beyond it. I did not take my eyes from the instrument during totality, my intention being to see these rings if there were any to see, and my first feeling when totality was over was one of failure because none had been visible."

Thermoscopic observations.—Mr. A. D. Anderson reports his observation with the thermospectroscope as follows: "As soon as the corona appeared the slit-tube (collimator) was pointed to it, the slit opened, the galvanometer balanced, and the lever which turns the grating moved so that the spectrum from the orange through the ultra-red traversed the face of the pile. When the extreme red was reached the lever was moved back to its original position. During totality the instrument was pointed four times to the corona, and four observations were made. The only result obtained was during the third observation when a decided deflection of the galvanometer index was noticed, in the direction indicating heat, from 54 to 57·5 on the scale, the index returning to its original position as the lever was moved past the point. A precisely similar and equal deflection occurred when the lever on the return stroke reached the same point." The position of the lever at the moment of the deflection was carefully marked, and after the eclipse it was found that a point in the spectrum of the *second order* just above G was upon the face of the pile. This would tend to indicate a heat line in the ultra-red with a wave length twice that of the coincident blue light. At the same time it must be admitted that the conclusion is doubtful, for, though it is not easy to explain what cause other than a coronal heat line could have produced the observed deflection, it is equally difficult to explain why the three other sweeps across the spectrum failed to show the same thing.

It is proper that I should here add that the American Academy of Sciences at Boston had placed at our disposal a considerable appropriation for this thermoscopic research; thanks, however, to the industry and ingenuity of Professor Brackett in constructing our apparatus, the generosity of Mr. Edison in giving us a tasimeter, the kindness of our railroad friends in the matter of passage and freights, and the liberal scale of the

original appropriation of the Green Trustees, it was not found necessary to draw upon this fund, though we are none the less grateful for its provision.

I need not occupy much space with a discussion of the photographic work. I think we failed in obtaining the desired results, simply because the lines we hoped to find in the ultra-violet did not exist there on this occasion, though it is of course certain that lenses of more light-gathering power would have increased our chances. That there was no fault with the chemicals and the manipulations is evident from the splendid success of Mr. Calley's pictures of the corona. In twenty-five seconds he obtained a far more extensive and better photograph than the same instrument gave in 1870 at Jerez with an exposure lasting through the whole totality, more than two minutes.

I ought not to close without a word of recognition of the courtesy and helpful kindness of our Denver friends. I do not know what they could have done that they did not, to aid us in our work and make our stay among them pleasant.

Princeton, September 6, 1878.

ART. XXXIII.—*On a Cause for the Appearance of Bright Lines in the Solar Spectrum*; by RAPHAEL MELDOLA, F.R.A.S., F.C.S., &c.*

IN July, 1877, Professor Henry Draper showed that oxygen and (probably) nitrogen are present in the sun's atmosphere, the spectral lines of these gases appearing as bright lines in the solar spectrum. The photograph accompanying Professor Draper's paper,† shows that the oxygen lines are bright, although not conspicuously so, upon a less luminous background.

The discoverer of this most important fact in solar chemistry does not offer any complete explanation of the exceptional behavior of the lines of these elements, but remarks that "it may be suggested that the reason of the non-appearance of a dark line may be that the intensity of the light from a great thickness of ignited oxygen overpowers the effect of the photosphere, just as, if a person were to look at a candle flame through a yard thickness of ignited sodium vapor, he would only see bright sodium lines and no dark absorption lines. Of course such an explanation would necessitate the hypothesis that ignited gases such as oxygen give forth a relatively large proportion of solar light."

The oxygen spectrum referred to in the above-mentioned paper is the well-known "line spectrum" seen when powerful

* From Phil. Mag. for July, 1878. † Nature, xvi, 364, August 30, 1877.

disruptive sparks pass through the gas. Dr. Schuster has recently succeeded in obtaining a second or "compound" spectrum of oxygen,* the fundamental lines of which he has shown with considerable certainty to be present as dark lines in the solar spectrum.

Since the publication of Professor Draper's discovery, I have given much attention to the consideration of a cause for the apparently anomalous brightness of the oxygen lines; and in the present paper I venture to advance an explanation which has recommended itself as being worthy of notice, not only because it offers a reconciliation of the known solar spectrum with the generally accepted views of the constitution of the sun's atmosphere, but likewise because it furnishes a suggestive hypothesis for the attack of many other obscure problems in solar physics.

1. I shall throughout this paper consider it to be established that the gaseous envelopes surrounding the sun succeed each other in the following order, commencing with the lowest:

(1) Photosphere; (2) Reversing layer; (3) Chromosphere; (4) Coronal atmosphere.

I also assume the truth of the hypothesis, first advanced by Johnstone Stoney,† who showed, from purely theoretical considerations, that in the sun's atmosphere the various elements must extend to heights which are, broadly speaking, inversely as their vapor densities. This view has, in my belief, been substantially confirmed by subsequent observation. Thus nitrogen and oxygen, having the respective densities 14 and 16 ($H=1$), would extend to a great height in the solar atmosphere, rising above sodium, calcium and magnesium, and having exterior to them the unknown substance giving the D_3 line (helium), hydrogen, and the element giving the coronal line "1474."

2. Two suppositions can be made concerning the sun's temperature. In the first place, it may be assumed that the temperature is so enormously elevated that no chemical compound is anywhere capable of existing in his atmosphere; in other words, dissociation may be considered to be complete. In the next place, it may be supposed that the temperature falls off sufficiently at some region of the outer portion of the sun's atmosphere for certain chemical combinations to take place.

3. Let us first assume that the temperature of the sun is so great that there is perfect dissociation throughout his whole atmosphere. Under these circumstances free oxygen would exist in the presence of electro positive elements; and, in accordance with Stoney's hypothesis, both this element and nitrogen (if present) would extend to a considerable height in

* Nature, xvii, 148, December 20, 1877.

† Proc. Roy. Soc., xvi, p. 2 and xvii, p. 1; Phil. Mag., August, 1868; Monthly Notices Roy. Astr. Soc., Dec., 1867; Lockyer, Phil. Trans., 1873, clxiii, 265.

the sun's atmosphere, rising as a necessary consequence, into regions which are cooler than that stratum which is cool enough to reverse the spectral lines of those metals having the smallest molecular mass, viz: Na, Ca and Mg.* Professor Draper's suggestion that the enormous thickness of incandescent oxygen may overpower the light of the photosphere, can only hold good, when considered in connection with this hypothesis, if the temperature of the upper portions of the oxygen atmosphere does not differ to any great extent from that of the lower and hotter portions. When, however, we bear in mind the comparatively low vapor density of oxygen, and consider at the same time to what an enormous height the hydrogen atmosphere extends, it appears probable that the height reached by oxygen would be such that the temperature of the upper portions of this gas would be considerably lower than that of the subjacent layers; so that any excess of radiation over that of the photosphere given out by the hottest portions of the incandescent oxygen would be obliterated by the absorption of the cooler portions above.

[The same reasoning can be applied if we suppose that the temperature of the oxygen falls off at some particular level; so that above this boundary the state of molecular aggregation of the gas corresponds to Dr. Schuster's "compound line" spectrum, while below this boundary the greater heat of the gas resolves its molecules into the atoms giving the ordinary line spectrum. The effect of this state of affairs is practically the same as would be brought about by annihilating a certain portion of the upper oxygen layers, since the two different molecular states of the gas give totally dissimilar spectra. We are thus reduced to an oxygen atmosphere of smaller extent, and the foregoing reasoning obtains.]

Ångström suggested † that the non-appearance of the lines of oxygen and nitrogen in the solar spectrum might be accounted for by supposing that, at the temperature of the sun, the specific absorptive power of these gases may be insufficient to reverse their spectra. This view, however, equally fails to account for the brightness of the lines in question.

4. Let us now make the not improbable assumption that the temperature of the sun's nucleus, photosphere, and reversing layer is so great that dissociation is perfect throughout these

* Stoney has shown (Proc. Roy. Soc., xvii, p. 14) that a gas or vapor, even when present in only small quantity, will nevertheless extend to nearly its full height in the solar atmosphere.

† He remarks (Recherches sur le spectre Solaire, Upsal, 1869, p. 37) that it is "très-probable que la température élevée du soleil ne suffit pas pour produire les raies brillantes de l'oxygène et de l'azote, et que par conséquent, même en supposant que ces corps existent actuellement dans le soleil, ils ne doivent pourtant pas occasioner de raies obscures dans le spectre solaire." He further suggests that oxygen and nitrogen may exist in the corona.

regions, but that somewhere in the higher regions, or above the chromosphere,* the temperature falls off sufficiently for some kinds of chemical combination to take place—say, in the present instance, for oxygen to combine with hydrogen. Under these circumstances we should have, concentric with, and exterior to, the chromosphere, a zone of combustion where oxygen and hydrogen, already at a very elevated temperature, enter into combination and become thereby raised to a state of more vivid incandescence.† All elements which, by virtue of their small vapor density, extended into the region of combustion, would be raised to incandescence by contact with the flaming gases, if not actually taking part in the combustion. Thus, according to the present hypothesis, we would not expect to find in the solar spectrum the bright lines of elements having a high vapor density.

5. The possibility of combination taking place in the higher regions of the sun's atmosphere is admitted by Stoney,‡ who states that "gases in the solar atmosphere which are kept asunder by the temperature of its lower strata may be able to combine in the cooler regions above." Such combination, although arising from the cooling down of gases previously at a temperature of dissociation, would nevertheless be attended with the evolution of heat, and would possess the character of true combustion. Professor Draper also remarks, in the paper before referred to,§ that "diffused and reflected light of the outer corona could be caused by such bodies (oxygen compounds) cooled below the self-luminous point."

6. The following considerations appear to give support to the view that oxygen extends into regions sufficiently reduced in temperature for combustion to take place:

The region which is called the chromosphere is distinguishable as such through what may be called an optical accident: it is that zone of incandescent hydrogen which is rendered visible by the telespectroscope; the true boundary of the hydrogen atmosphere lies far above the visible chromosphere; and from this latter zone outward the temperature falls off rapidly.

* It is generally admitted that the true height of the chromosphere is considerably greater than that seen by means of the telespectroscope, since the amount of dispersion necessary to weaken the scattered light of our atmosphere must weaken and shorten the hydrogen lines by which the chromosphere is revealed.

† It is well known that the oxyhydrogen flame does not show the lines of either of the burning gases. In the sun, however, the conditions are probably very different. The combining gases may be largely diluted with other inactive gases. Furthermore the pressure, as shown by the researches of Frankland and Lockyer (Proc. Roy. Soc., xvii, p. 288), is apparently far less in the upper regions of the chromosphere than in our own atmosphere. Both these causes would conspire to raise the point of ignition of the gases in question, so that a much higher temperature would be necessary to bring about combination than if they were undiluted and under greater pressure.

‡ Proc. Roy. Soc., xvii. § Loc. cit., p. 366.

Now it has been well established by observation, that metals of great molecular mass, such, for example, as those of the iron group, are frequently thrown high up into the chromosphere.* Thus, if gases of great vapor-density are occasionally injected into the chromosphere, gases composed of molecules of comparatively small mass, such as those of oxygen and nitrogen, would probably extend permanently into regions far above the chromosphere, and which are therefore at a much lower temperature than that zone.

The elements chiefly concerned in producing selective absorption in sun spots, as shown by the local thickening of their spectral lines, are all elements of high vapor density compared with oxygen—viz: Na, Mg, Ca, Ba, Fe, Ni, Cr and Ti; from this it appears that the disturbances producing these phenomena must extend low down in the chromosphere. The band spectra occasionally seen in the nuclei of sun spots† appear to indicate that in these regions the temperature is sometimes sufficiently reduced to admit of the formation of compounds. If therefore the temperature of the solar atmosphere above the spot layer is low enough to permit of chemical combination taking place,‡ even when the portions of the atmosphere concerned are swept down into the subjacent spot cavity, it follows that the layer into which oxygen extends (which, as we have seen, must be far above the spot layer) would likewise be cool enough to allow of the formation of compounds.

7. It will help to give greater precision to the hypothesis of a zone of combustion, if we follow the course of a ray of light supposed to be emitted by the photosphere and received in the spectroscope of a terrestrial observer. Passing through the reversing layer, the ray undergoes that selective absorption which gives rise to the Fraunhofer lines; and if its spectrum could be

* Lockyer, Proc. Roy. Soc., xviii; Young, Journ. Frank. Inst., Sept., 1869 and Oct., 1870; also "Nature," vol. iii, p. 111, and vol. vii, p. 17; Respighi, Atti d. Real. Accad. d. Linc., 1872; Tacchini, Comptes Rendus, lxxvi, p. 829; H. C. Vogel, Beobachtungen, 1872; and numerous other observers.

† Professor Young states (Nature, vii, p. 109) that in the spectrum of a sun-spot he observed "between C and D some very peculiar shadings, terminated sharply at the less refrangible limit by a hard dark line, but fading out gradually in the other direction at a distance of three or four Kirchhoff's scale divisions." This answers in all respects to the spectrum of a compound body: indeed this excellent observer subsequently suggests that these bands "seem to point to such a reduction of temperature over the spot nucleus as permits the formation of gaseous compounds by elements elsewhere dissociated." In the spectrum of a sun spot recently observed at the Royal Observatory, Greenwich (Monthly Notices Roy. Astr. Soc., Nov. 9, 1877), a dark shaded band was seen at about wave-length 6380, "sharp toward the blue and shaded off toward the red. Nothing seen on the sun to correspond with it."

‡ If these band spectra are regarded as the spectra of elements in the stage of molecular complexity corresponding to the molecule giving the band spectrum of iodine, or Roscoe or Schuster's new spectra of Na and Ka (Proc. Roy. Soc., xxii, 362), the argument remains unaffected, since these band spectrum-giving molecules are spectroscopically equivalent to the molecules of compound bodies.

examined immediately after its emergence from this layer, the oxygen (and nitrogen) lines would appear dark, but less conspicuous than the metallic lines, for reasons which will be entered into later on in this paper.* After traversing the chromosphere the ray reaches the zone of combustion, in which region, owing to the increased temperature, the lines of all elements which extend so far would tend to be reversed into bright lines of radiation.†

[I say "tend to be reversed," because whether they would actually become so depends upon the specific absorptive power of the elements concerned for the rays in question. Thus, let there be two gases, A and B, of which the spectral lines are $A\alpha$, $A\beta$, $A\gamma$ and $B\alpha$, $B\beta$, $A\gamma$ respectively; and let the specific absorptive power of A be greater at a given temperature than that of B. Imagine A and B to be raised to incandescence, and placed in front of a source of white light at a higher temperature, and let this combination be called the "first system." On examination we should see the continuous spectrum crossed by dark lines, $A\alpha$, $A\beta$, $A\gamma$, $B\alpha$, $B\beta$ and $B\gamma$, of which the first series would be darker than the second. Now conceive the radiation of the whole system to be weakened by general absorption or by removal to a distance. The lines of B would first disappear; so that if we imagine a mixture of A and B ("second system") to be heated to incandescence and placed between the first system and the observer, the B lines might appear bright on a background of continuous spectrum, while the A lines remained dark, although weakened by the radiation of the second layer of mixed gases.]

Thus, if the sun's envelopes exterior to the zone of combustion could be stripped off, we should see the solar spectrum with the lines of oxygen (and nitrogen) bright, and the hydrogen lines probably dark but much fainter than now seen.

8. The reversal of the oxygen (and nitrogen) lines into bright lines by the increased temperature of the region of combustion is rendered possible, even with the intense light of the photosphere as a background [and if, as most probably

* The question here arises as to what order of oxygen spectrum we should expect to find at the temperature of the reversing layer. Dr. Schuster seems inclined to believe that the temperature may be such as to give the "compound" spectrum of this gas (Nature, vol. xvii, p. 148). The recent observations of Lockyer upon the calcium spectrum (Proc. Roy. Soc., xxiv, 352) tend to show that the temperature of this layer is intermediate in dissociation power between that produced by a small coil with jar and a large coil with jar, a temperature which I am disposed to believe would produce a state of molecular dissociation corresponding to the line spectrum of oxygen.

† It is possible that the temperature of the chromosphere may fall off at some particular level, so as to give above such boundary the "compound" oxygen spectrum. Should this be the case, the higher portion of the chromosphere may obviously be left out of consideration, so far as relates to its absorbing action on the line spectrum of oxygen.

would be the case, the temperature of the said region of combustion is lower than that of, the photosphere], because the light radiated by the latter has undergone almost its maximum amount of weakening before reaching the zone of combustion, not only on account of the distance of this last region from the photosphere, but also because of the absorption, both selective and general, which the light has undergone in passing through the intervening reversing layer and chromosphere.

9. We have next to turn our attention to that part of the sun's atmosphere exterior to the zone of combustion, in order to account for the fact that the hydrogen lines appear so intensely dark while the oxygen lines are bright. The explanation which I venture to suggest is based upon a wide survey of the general spectroscopic characters of the elements.

10. At the temperature of incandescence, the characteristic lines in the spectra of any elements which are compared may be of very different intensities. Thus Cappel has shown,* by a series of quantitative determinations made at the temperature of a Bunsen burner and of an induction spark, that very different amounts of the metals experimented upon can be detected by means of the spectroscope. The characteristic lines of an element are those which Lockyer has shown to be the *longest*. Interpreting such facts by the aid of the molecular theory of gases (and making due allowance for the fact that the characteristic lines of the spectra being compared may occur in parts of the spectrum not *visually* comparable so far as regards intensity), we should say that some kinds of molecules can have certain internal vibrations more readily excited than is the case with other kinds. From the relationship which exists between radiation and absorption, it follows that molecules which have the most sensitive *radiative* organization have likewise the most sensitive *absorptive* organization.

11. The non-metals are distinguished, as a group, from the metals by the greater complexity of their spectra (which more resemble the band spectra of compound bodies), and also by their comparative insensitiveness to the spectroscope. Many of the metals are known to give band spectra at low temperatures; but these break up into line spectra at high temperatures. On the other hand, the band spectra of many non-metals bear temperatures high enough to break up the band spectra of metals without being resolved into line spectra. We might thus have a mixture of two vapors, one metallic and the other non-metallic, at the temperature of incandescence, the former giving a line spectrum and the latter a band spectrum. If we imagine the temperature of such a mixture of vapors to be raised to the point at which the band spectrum of the non-

* Pogg. Ann., cxxxix, 628 (1870).

metal breaks up, we should get a line spectrum from both elements; but the metallic lines would be more intense* than those of the non-metal, owing to the greater sensitiveness of the metallic molecule. We should thus have realized the conditions laid down in a former paragraph (7), where A would then represent the metallic, and B the non-metallic vapor.

12. It now remains to show the applicability of the foregoing principles to the case under consideration.

The oxygen and hydrogen of the sun's atmosphere will, for the sake of simplicity, be exclusively considered. These gases represent the metallic and non-metallic vapors of the last paragraph. The photosphere, reversing layer, and chromosphere represent the "first system" of paragraph 7—i. e. the source of white light, with the mixture of two vapors of different specific absorptive powers in front. The oxygen and hydrogen of the zone of combustion represent the second layer of incandescent gases of paragraph 7, supposed to have been placed in front of the first system, the total radiation of which is imagined to have been weakened by general absorption or by removal to a distance. It has been shown in paragraph 8 that the total radiation of the photosphere has probably undergone a great amount of weakening from both these causes. Thus the spectrum of a ray which reaches the zone of combustion would exhibit (supposing the zone of combustion and all exterior to it to be stripped off) the lines of oxygen and hydrogen dark, but those of the former much fainter than those of the latter. The action of the incandescent gases of the zone of combustion upon such a spectrum would be to reverse the oxygen lines and to weaken those of hydrogen.

The temperature of the region outside the zone of combustion must fall off, so that any oxygen which might there exist† would be in the state of molecular aggregation corresponding to the compound spectrum, and would thus be without action on the bright-line spectrum of this gas, but would give rise to the dark lines of its compound spectrum. The hydrogen of the region now under consideration by further absorption intensifies the lines of this gas. Thus the solar spectrum as now known is shown to be in complete accordance with the hypothesis here advanced.

* "In a tube containing both nitrogen and aqueous vapor, the *lines* of hydrogen (spectrum II order) made their appearance at the same time as the spectrum of bands (I order) of nitrogen, whence it follows that the lines of hydrogen are visible in a temperature in which the lines of nitrogen do not appear" (Schellen's Spectrum Analysis, p. 171). So also Frankland and Lockyer found that in a tube containing hydrogen and nitrogen, the lines of the latter gas under certain conditions of pressure could be made to disappear entirely, while the hydrogen lines under all conditions remained visible (Proc. Roy. Soc., xvii, 454).

† It may be supposed that the oxygen atmosphere terminates with the zone of combustion, in which case Dr. Schuster's new oxygen spectrum must be produced by the absorptive action of the gas in the upper regions of the chromosphere (see also note to paragraph 7).

The hypothesis of a zone of combustion in the higher regions of the sun's atmosphere, as already stated, furnishes suggestions for the explanation of many observed facts in solar physics hitherto unaccounted for.

I will first call attention to the intense brilliancy of the line D_3 in the spectrum of the chromosphere, and the extreme faintness of the corresponding dark line in the solar spectrum.* If we consider to what an enormous height this element extends, bearing also in mind that it must consequently reach into comparatively cool regions, and that its radiative (and therefore absorptive) powers are very great, it seems improbable that the vast thickness of this gas which must be traversed by a ray of light emitted by the photosphere should be barely sufficient to reverse its spectrum. If the existence of a zone of combustion be granted, however, this region becomes the source of radiation of all gases which extend so far. Thus in the case of the D_3 element, which reaches nearly the same level in the sun's atmosphere as hydrogen, the stratum of gas exterior to the zone of combustion is, on the present view, alone concerned in reversing the line under consideration; and this stratum may be of insufficient thickness to produce any marked absorption. The "1474" substance, however, which rises far above hydrogen, appears to exist in sufficient quantity exterior to the supposed region of combustion (or its specific absorptive power is sufficiently great) to produce a marked reversal in the solar spectrum.†

The hypothesis advanced in the present paper does not necessarily imply (at least under existing solar conditions) the production and accumulation of large quantities of compound bodies in the higher regions of the sun's atmosphere. The zone of combustion may be, so to speak, only a local phenome-

* This line was seen in July, 1877, by H. C. Russell, at Sydney. The observer states that "it is a difficult line to see, and only to be made out with high powers." The greatest dispersion of the spectroscope employed was equal to eighteen 64° prisms (Month. Not. Roy. Astr. Soc., Nov. 9, 1877, pp. 30–32).

† Lockyer has recently shown (Compt. Rend., lxxxvi, 319; Proc. Roy. Soc., xxvii, 282) that the blue line of lithium (w.-l. 4603) is represented in the solar spectrum, while the red line (w.-l. 6705) has not hitherto been detected. The question suggests itself whether the absence of this last line may not also be connected with the existence of a region of combustion. The low atomic weight of lithium would lead to the belief that this element extends to a great height in the solar atmosphere. Thus the zone of combustion might be the source of lithium radiation, and at the temperature of the sun the blue line may be the longest (as appears probable from the fact that this line requires a high temperature for its development); so that the vapor above the region of combustion may be sufficient to reverse the blue, but insufficient to reverse the shorter red line. I would here ask whether the bright red line so frequently seen in the spectrum of the chromosphere by Lockyer (Phil. Trans., 1869, pp. 428 and 429), and described as being less refrangible than C, may not be the missing lithium line? I may add that a line less refrangible than C has also been frequently seen by Respighi at the base of prominences. It is highly significant that during the eclipse of 1868 a blue line between F and G was seen by Rayet in the spectrum of a prominence. This is the position that would be occupied by the lithium line w.-l. 4603.

non confined to a thin shell of the sun's outer envelopes; and compounds formed would be rapidly decomposed both by dissociation and chemical reduction by being swept down into the underlying hotter regions by the convection currents which take place on such an enormous scale in the sun's atmosphere. The heat of the zone of combustion may also contribute to the dissociation of compounds formed therein.*

It is well known to spectroscopists that the solar spectrum is never absolutely free from the so-called "telluric" lines, which have been shown to owe their existence to the aqueous vapor of our atmosphere. It is possible from the present point of view that these lines may be partly caused by aqueous vapor in the higher regions of the sun's atmosphere.† Should there be any connection between the activity of combustion and the formation of sun spots, a rigorous comparison of the "telluric" lines in the solar spectrum carefully observed (or still better, photographed) at different periods of the spot cycle would be of the highest possible interest. Thus it may be suggested that the solar combustion varies periodically in activity—combination being in excess of dissociation during one half of the cycle, and dissociation being in the excess during the other half, when the heat resulting from the combustion, having reached its maximum, tends to decompose the compounds formed. This view points to the belief that the connection between the sun spot period and the period of variation of magnetic declination may be due to a common cause—the activity of combustion in the sun's atmosphere and the resulting variation either in the amount of free oxygen, or in the magnetic characters of this gas consequent on variation of temperature.

Sir William Thomson's theory of the dissipation of energy leads to the belief that the sun, like other stars, is gradually cooling down. Thus we should be led to infer *à priori* that there must be a period in the life of a star when compounds can begin to form. Such combination would begin in the outer and cooler portions of the star's atmosphere, as required by the present hypothesis, and would be attended with the development of the heat representing the energy of chemical separation. As the star goes on cooling down, the zone of combustion, at first a mere shell, would gradually encroach upon the central regions, and a star having permanently bright

* See Bunsen's experiments on the combustion of different mixtures of CO and H with O (Pogg. Ann., cxxxi, 161); also Berthelot On the Chemical Equilibrium of C, H and O (Bull. Soc. Chim., [2] xiii, 99).

† I may here recall the much discussed observation of Secchi, who asserted the existence of water vapor in the neighborhood of sun spots (Compt. Rend., lxviii, 238). Janssen also, in 1864, observed aqueous vapor in the atmosphere of Antares, and, in 1868, in the atmosphere of many other stars (Compt. Rend., lxviii, p. 1845).

lines in its spectrum would result. In the earlier stages of what may be called the "chemical period" of a star's history—a period into which our sun may be supposed to have entered—the lines of the non-metallic elements would alone appear bright, for the reasons detailed in the foregoing portions of this paper (paragraph 11), and, owing to their comparative faintness, would be lost at the enormous distances which the light of the star has to traverse before reaching our spectroscopes. When, however, the region of combustion had encroached sufficiently to reverse the metallic lines, these would shine out with much greater brilliancy than the non-metallic lines, and we should have a background of continuous spectrum crossed by the bright lines of the metals of smallest vapor density. Such stars would only be expected among those which are, so to speak, in the latest phase of their "chemical period." It is significant that γ Cassiopeiæ, β Lyræ and η Argo, three stars which show bright lines in their spectra, all have sufficiently complex spectra to warrant the belief that they have entered upon a late phase of their existence. Before the actual reversal of the metallic lines there must exist a period in the life history of many stars when the temperature and extent of the zone of combustion is such as to obliterate the dark lines of those metals which will ultimately appear as bright lines. Such appears to be the case with the hydrogen in α Orionis; and according to the present views it might perhaps be predicted that this star will sooner or later show a permanent hydrogen spectrum of bright lines. It is conceivable that in certain cases the composition of a star's atmosphere may be such as to permit a considerable amount of cooling before any combination took place among its constituents; under such circumstances a sudden catastrophe might mark the period of combination, and a star of feeble light would blaze forth suddenly, as occurred in 1866 to τ Coronæ Borealis. In other cases, again, it is possible that the composition of a star's atmosphere may be of such a nature as to lead to a state of periodically unstable chemical equilibrium; that is to say, during a certain period combination may be going on with the accompanying evolution of heat, till at length dissociation again begins to take place. In this manner the phenomena of many variable stars may perhaps be accounted for. On the whole, the possibility of actual combustion taking place in the atmosphere of a slowly cooling star previously at a temperature of dissociation does not seem to me to have had sufficient weight attached to it; and in concluding, I would point out the important factor which is thus introduced into calculations bearing upon the age of the sun's heat in relation to evolution.

London, June 6, 1878.

ART. XXXIV.—*On the Explosion of the Flouring Mills at Minneapolis, Minnesota, May 2, 1878, and the Causes of the same;* by S. F. PECKHAM.

As I was sitting at the tea-table on the evening of May 2d, I was startled by a noise that sounded as if something as heavy as a barrel of flour had been tipped over on the floor above. A few seconds later the sound was repeated, and we all ran to the door which commanded a full view of the falls and manufacturing portion of the city. An immense volume of black smoke enveloped the spot where the Washburn A Mill had stood, and a perpendicular column of smoke was projected into the air above the elevator at least four hundred feet. The Humboldt and Diamond Mills were directly behind the elevator from the place where I stood. A heavy wind was blowing from a point a little to the east of north, a direction from the Washburn A Mill toward the elevator and the other two mills. In less than two minutes from the time of the first explosion, the elevator, which was 108 feet high, was wrapped in flames from top to bottom. If the structure had been saturated in oil the flames could not have spread much more rapidly. In five minutes flame and smoke were pouring from every window in the Day & Rollins, Zenith and Galaxy Mills, which were between the Washburn A Mill and the river, producing a conflagration which from ordinary causes would not have gained such headway in two hours. Six flouring mills, the elevator, a machine shop, blacksmith's shop and planing mill, with a number of empty and loaded cars, were in flames in five minutes from the time fire was first observed by any one who survived the disaster.

From my own point of observation, which was about a mile distant, but two distinct explosions were heard; others nearer heard three, the first not as violent as the other two; while those nearer still heard in addition a sound which they described as a succession of sharp hisses, resembling the sound of burning gun-powder. Those observers to the windward, whose attention was arrested by the light produced, beyond the distance of half a mile, heard only one or two reports or failed to hear any report at all. From all the testimony in reference to sound it appears that the blow upon the air was not sufficiently sudden to produce a penetrating sound, but rather a dull, heavy blow, which was not communicated laterally to any great distance.

Burning wheat or flour was smelled for several minutes before the explosion by persons in such a position that the wind would carry the odor to them. Smoke was also seen issuing from what was known as the exhaust flour-dust spout

of the Washburn A Mill for several minutes preceding the explosion.

At the instant the explosion occurred all observers agreed that the Washburn A Mill was brilliantly illuminated from basement to attic. The illumination was reflected from the water at and around the falls in such a manner as to remind one observer of the effect of a brilliant sunset. Another compared it to the reflection of sunlight from windows when the sun is near the horizon. Still another, who was crossing the lower bridge, had his attention called to what appeared to be a stream of fire, which as he described it, issued from a basement window and went back again. Immediately thereafter each floor above the basement became brilliantly illuminated, the light appearing simultaneously at all the windows, only an appreciable interval of time intervening as the stories ignited one after the other. Then the windows burst out, the walls cracked between the windows and fell, and the roof was projected into the air, followed by an immense volume of smoke and flame which ascended to an estimated height of from six to eight hundred feet. As the column of smoke was expanded and borne off upon the wind, brilliant flashes resembling lightning passed to and fro.

Two men, so near the Humboldt Mill that they were nearly buried by the falling rubbish, and on the opposite side from the Washburn A Mill, heard a loud report distinctly while the walls of the Humboldt Mill were still standing and at the same time were knocked down. Immediately after they saw flames issuing from the basement windows of the Humboldt Mill and at the same instant, before they could regain their feet, they experienced a second shock and miraculously escaped being buried beneath the falling walls.

The enormous and sudden displacement of air which followed the explosion, and the tremendous force which was consequently exerted laterally, was shown in the condition of the round-house of the Chicago, Milwaukee, and St. Paul railroad, and the broken windows in all directions. The round-house was a wooden structure about forty or fifty feet from the Diamond Mill. The sills were drawn out toward that mill until the building burst, letting a part of the roof fall in and leaving the sides standing at a sharp angle. Ordinary windows, and those of strong plate-glass on Washington avenue one-fourth of a mile distant, were projected into the street. Not only the glass but the sash went out bodily, particularly in the lower stories of the buildings. Persons on the river at the water's edge noticed a displacement of the water producing a wave estimated to be eighteen inches high, before they heard the report of the explosion.

Whole sheets of the corrugated iron with which the elevator was covered, measuring eight by two feet but quite thin, were picked up on the east side of the river more than two miles distant, and pieces of six-inch flooring from two to ten feet long were carried to intermediate points.

An examination of the ruins of the several buildings showed that the walls of the Humboldt Mill lay upon those of the Diamond Mill, and those of the Diamond Mill upon those of the west end of the Washburn A Mill, showing that the buildings did not explode simultaneously but successively. The Washburn A Mill evidently exploded first from fire originating within it, and the high wind prevailing at the time carried the *flame* into the adjoining mills to the south and away from the mills next the river. There was enough burning middlings and flour thrown through the broken windows of the latter mills to set them on fire, but they did not explode. Some significance may attach to the fact that the three mills that exploded were all running with more or less open French middlings purifiers, while the three that did not explode had been shut down for several days. There is no question but that the French purifiers project a great deal more dust into the atmosphere of the mills than those that are enclosed, but I have no doubt that in *any* flouring mill sufficient dust accumulates upon beams and machinery to produce an explosive atmosphere if from any cause this dust is scattered into the air and flame is communicated to the mixture while the dust is suspended.

There was less than a barrel each of lard oil, lubricating oil and high-test kerosene in the Washburn A Mill at the time of the explosion.

There is absolutely no proof that any explosive material other than is produced in the manufacture of flour from wheat was in any one of the buildings destroyed, in the cars around them or in the neighborhood. The testimony of mill-wrights conclusively showed that fire produced by heated bearings is of such extremely rare occurrence in flouring mills as to practically exclude such a cause.* No suspicion of incendiarism has ever been expressed.

A slight fire, the effects of which were in no wise serious, occurred in the Washburn A Mill about three months before the explosion. It was discovered from the outside of the mill that smoke was issuing from a spout or conductor that discharged the air that was drawn through between the stones.

* These gentlemen concurred in the statement that the spindle which carries the stone had been known to become *welded* into the socket in which it revolved, stopping the stone. When asked if the friction produced a welding heat, one replied, "no, no where near it." It must be an example of perfect metallic contact, producing cohesion.

The object for which the air is drawn through is to cool the stones and to carry off the vapor produced from the wheat by the rise of temperature due to friction. In this case the effects of *fire* were traced back from the outside of the building to one of the sets of stones on the north side of the mill used for grinding middlings. The effects of *flame* however did not extend beyond the blower which produced the exhaust. This led to the conclusion that the fire did not enter the dust-house, although the smoke must have passed through it. It is supposed that the fire was caused by friction between the stones, they having run dry from one of the causes that may produce dry stones.

In answer to enquiries made of several millers in the Minneapolis mills, I found them uniformly of the opinion that the meal or flour as it left the stones had a temperature of about 100° F. or less. A number of careful experiments, made with an ordinary chemical thermometer, showed that the wheat enters the stones from the dryers at a temperature of fully 100° F. and that it leaves the stones at 120°–130° F. The temperature of the ground middlings as it left the stones averaged about ten degrees higher.

It was also the concurrent testimony of millers and mill owners that dry stones are of comparatively frequent occurrence, and that they are practically unavoidable. I am convinced that in the Washburn A Mill the frequency of danger from dry stones was considerably increased in consequence of the large number of stones in the mill, and especially from the fact that so few men were employed having the immediate oversight of the stones. Only two men were employed at the same time for the forty-two run of stone, a number inadequate for that supervision which so important a matter demands, as it is impossible from the large space occupied by so many stones and the noise incident to their action, that even with the usual signals employed dry stones should be detected as soon as they become a source of danger.

Obstruction of the feed from any one of a number of accidental causes will produce dry stones. The danger arises from the friction of the stones heating the last portion of the grist that remains between the stones to a temperature sufficient to char it, or convert it into a substance resembling tinder, which would readily ignite from a spark produced by the stones striking together. Another source of danger arises from nails or gravel passing between the stones with the grist and increasing the friction, producing either a rise of temperature or a train of sparks; perhaps both.

I am aware that numerous instances of dry stones can be cited that have proved perfectly harmless. An instance is on

record in which a run of stone ground each other all night with no other result than the complete removal of the grooves which gave the stones a cutting face. On the other hand, cases have occurred in which the grooves became filled with charred wheat of a dark-brown color, packed into them so solidly as to require a mill-pick for its removal. It requires no argument to show that this tinder thus formed, would become ignited from a train of sparks that would inevitably follow contact of the stones as the grist became compacted or completely removed from between them. It was found by experiment* that masses of flour that had become heated and charred, ignited readily and smouldered, but were inflamed with considerable difficulty; but it should be borne in mind that a number of sets of these stones are connected with a common spout or conductor, through which a strong current of air is being continually drawn and which is filled with a dense cloud of very fine particles of starch (chiefly) heated to a maximum temperature of 140° F. Experiment also proved that the proper mixture of flour-dust and air would not burn explosively except when brought in contact with *flame*. White-hot wires and glowing charcoal only burned the particles in contact with them. But it was found that burning pellets of charred wheat and flour would ignite wood which a strong draft of air readily fanned into a blaze. Under the conditions previously stated with a draft of air passing through the dry stones strong enough to convey the pellets of smouldering tinder into the common wooden conductor an explosion becomes possible.

It is urged that these conductors are damp from condensed moisture, and also that a large amount of moisture escapes from the wheat and is conveyed away by the current of air. This loss is no doubt correctly estimated at from five to six per cent. It is, however, chiefly during the first grinding of the raw wheat that this loss is experienced. The middlings is dryer, is ground at a higher temperature and is ground finer, producing more dust. The higher temperature renders the material more inflammable and at the same time ensures a more complete solution of the vapor in the current of air. Moreover, the first fire in the Washburn A Mill was traced directly to a set of stones which ground nothing but middlings, and all that is known concerning the origin of the fire that produced the explosion confirms the supposition that that fire originated in a set of stones on the opposite side of the mill, which was one of six sets, all of which were used exclusively for grinding middlings, discharging into a common spout or conductor which communicated directly with a dust-house in which the

* Experiments made by Professor L. W. Peck before the coroner's jury.

dust settled to the amount of several hundred pounds a day. An explosion in this conductor, communicating *flame* to the dust-house, would scarcely fail to cause the successive explosions of the dust-house and the different stories of the mill, the shock of the first explosion being sufficient to throw the dust of the mill into the air.

The opinion expressed by one of the witnesses at the inquest, "that stones are liable to run dry at any time by accident," and that "dry stones can hardly be avoided by any amount of foresight," appears to be generally entertained by millwrights, millers and mill owners. Let it be granted that all experience shows that ninety-nine per cent of dry stones injures nothing but the stones themselves, the one per cent of residue is burthened with fearful possibilities. If dry stones cannot be prevented in small mills where one miller has charge of perhaps six run of stone, the danger is more than proportionally increased in a mill where one man has charge of twenty run, both with reference to prevention and detection. The problem therefore for the consideration of parties immediately interested is, how to prevent or detect dry stones, particularly those used for grinding middlings. This practical problem appears to be fundamental and one compared with which all others are without much importance. It is true that but few millers are without their experience of minor explosions or flashes resulting from careless use of lanterns or open lights. Indeed, I have been profoundly impressed with the generally innocent reputation of flouring mills when considered in the light of the immense number of accidents well-known to millers and insurance companies; a number surprisingly large if confined to those occurring in the States of Minnesota and Wisconsin within a few years past. The remedy in such cases is so obvious that the most ordinary care and intelligence is sufficient.

University of Minnesota, Minneapolis, June 30, 1878.

ART. XXXV.—*On Bárcenite, a new Antimonate, from Huitzuco, Mexico;* by J. W. MALLET.

AMONG some Mexican ores given me by my friend, Señor Mariano Bárcena, one of the Foreign Commissioners to the Philadelphia Exhibition of 1876, and now Director of the Central Meteorological Observatory of the City of Mexico, there were several specimens of a heavy, nearly black mineral, which accompanies Livingstonite* at Huitzuco in the State of Guer-

* Sulphide of antimony, mercury and iron; described by Bárcena himself (Naturaleza, 1874 and 1875, pp. 35 and 172). Sulphur, cinnabar, stibnite and valentinite are said to be found at the same locality.

rero. This turns out on examination to be an antimonate of hitherto undescribed character, mixed with finely divided mercuric sulphide and antimonic acid.

The specimens given me, one or two of which originally weighed more than half a kilogram each, while I saw in Señor Bárcena's possession much larger masses, were for the most part of columnar structure, with long, blade-like prisms of imperfect development. They have the general aspect of those of stibnite and Livingstonite, from the latter of which species this has probably been formed by oxidation. In some parts the structure was finely granular or quite compact, with occasional honeycombing by little cavities and pores. Indications of cleavage were observable parallel to one prismatic face, but this was in all probability due merely to the pseudomorphous structure of the material. Brittle. Fracture tolerably even. Hardness = 5·5. Specific gravity of the mineral in powder, previously boiled with water to remove air, = 5·343 at 20° C.; lumps gave notably lower results, owing to porosity. Luster dull, earthy, on some surfaces inclining to resinous or pitch-like. Opaque. Color very dark gray, nearly black. Streak ash-gray, with a slight greenish tint. Faces of the pseudomorphous crystals sometimes coated with red pulverulent cinnabar, and sometimes with yellowish white antimony ocher.

Heated alone before the outer blowpipe flame, the mineral decrepitates slightly, turns white or nearly so, and becomes rounded with some difficulty on the edges, giving off a little white fume; in the reducing flame the fume becomes more abundant from reduction of metallic antimony, followed by volatilization and burning in the outer edge of the flame, which is colored greenish-blue. A fragment heated in a closed glass tube gives off water, metallic mercury, black mercuric sulphide, and a very little oxide of antimony; in a tube open at both ends the whole of the mercury is deposited in the metallic state, the sulphur being burned off, and in a good draught of air through the tube more oxide of antimony is carried along and deposited. A well marked white antimonial sublimate is produced by heating on charcoal, and if sodium carbonate be added the antimony is easily reduced to little metallic beads. The mineral in powder is largely dissolved, in the oxidizing flame, by borax or microcosmic salt to a clear, colorless glass, which becomes turbid in the reducing flame.

The mineral, even when finely pulverized, is insoluble in hydrochloric or nitric acid, though this be concentrated and at the boiling temperature. Very slightly acted on by boiling solution of ammonium sulphide. On boiling with a strong solution of sodium hydrate, filtering, acidulating, and passing in hydrosulphuric acid, an orange precipitate is obtained in no great

quantity. Hydrogen passed over the powder at a red heat easily reduces metallic antimony, which can then be attacked by acids.

The quantitative analysis was made by Mr. J. R. Santos, of Guayaquil, Ecuador, using carefully selected specimens, free from visible impurity, and repeating several of the principal determinations.

He obtained—

			Atomic ratios.
Sulphur		2·82	·088
Mercury		20·75	·104
Calcium		3·88	·097
Antimony		50·11	·418*
Oxygen (by difference)		17·61	1·101
Water: constitutional	3·50	4·73	·194
Water: lost below 130° C.†	1·23		
Silica		·10	
		100·	

The sulphur was pretty well ascertained to exist altogether in combination with mercury, since by gentle heating until this metal was all driven off the white residue was found to contain but an unweighable trace of sulphur; moreover the ore in the finest powder was scarcely acted on by ammonium sulphide, and the partial solution obtained with caustic soda gave no orange precipitate of sulphide of antimony on addition of an acid until hydrosulphuric acid gas had been used. Deducting then the whole of the sulphur and an equivalent amount of mercury (for mercuric sulphide) from the above, the remaining figures represent—

	Atomic ratios.
Hg	16
Ca	97
Sb	418
O	1101
H_2O	194

corresponding to

HgO	16	= R″O	113·	= nearly 4·
CaO	97			
Sb_2O_3			28·5	1·
Sb_2O_5			180·5	6·3
H_2O			194·	6·8

* Using the atomic weight 120 for antimony, the correctness of which has been rendered most probable by the recent research of Professor J. P. Cooke.—This Journal, February, 1878, p. 123.

† There was scarcely any appreciable loss of water (which was of course determined *directly*) from this temperature or less up to more than 200° C.

or

$R''O$	4
Sb_2O_3	1
Sb_2O_5	5

with

$$\left.\begin{array}{ll} Sb_2O_5 \ldots\ldots & 1\cdot3 \\ H_2O \ldots\ldots & 6\cdot8 \end{array}\right\} = 1:5$$

Hence the mineral is apparently a mixture of mercuric sulphide, antimonic acid (Fremy's—$Sb_2O_5 . 5H_2O$,* or $H_4Sb_2O_7 . 3H_2O$), and an antimonate of calcium, mercury, and triad antimony of the formula $\left.\begin{array}{l}(R''O)_4 \\ Sb_2O_3\end{array}\right\} . (Sb_2O_5)_5$, corresponding to a normal antimonate—$M_2'O . Sb_2O_5$ or $M'SbO_3$.

It differs noticeably from all the natural antimonates hitherto described, in that these are strongly basic, while the mineral now described contains a surplus of the electronegative antimony as antimonic acid over and above the amount necessary to form a normal antimonate with the electropositive metals present. Calculating on the basis of the atomic weight of $Sb = 120$, monimolite agrees very fairly with the formula $(R''O)_4 . Sb_2O_5$, or $R_4''Sb_2O_9$; Romeite comes nearest to $(R''O)_6 . (Sb_2O_3)_3 . (Sb_2O_5)_2$, or $R_6''Sb_6'''Sb_4^vO_{25}$ (Dana makes this $(R''O)_3 . Sb_2O_3 . Sb_2O_5$; ammiolite of Domeyko agrees best with $(CuO)_3 . Sb_2O_5$, or $Cu_3Sb_2O_8$, while Rivot's analysis of a similar mineral from Chili comes fairly near $(CuO)_8 . (Sb_2O_3)_3 . (Sb_2O_5)_3$, or $Cu_4Sb_3'''Sb_3^vO_{16}$ (which may perhaps mean $(CuO)_3 . Sb_2O_3 . Sb_2O_5$, corresponding to Dana's formula for Romeite); while in Bindheimite the atomic ratio of $PbO : Sb_2O_5$ derived from the analyses recorded, ranges from $1\frac{1}{4} : 1$ to $2\frac{3}{4} : 1$, even assuming that we have here a hydrous salt instead of a mixture of antimonic acid with one of more strongly basic character.

I propose to name this mineral Bárcenite (accented on the first syllable) in remembrance of the worthy Mexican gentleman from whom I received it; his scientific work and zeal for scientific progress are honorable to himself and to his country.

University of Virginia, August 13, 1878.

* Volgerite was described as a natural antimony ocher having this composition. Dana remarks (Mineralogy, p. 188), that the only published analysis, by Cumenge, on material from Constantine, Algeria, corresponds to $Sb_2O_5 . 4H_2O$. By my calculation Cumenge's figures lead rather to $Sb_2O_4 . 3H_2O$, or $Sb_2O_3 . Sb_2O_5 . 6H_2O$.

ART. XXXVI.—*On the Intra Mercurial Planets*; by Professor J. C. WATSON; from letters to the editors, dated Ann Arbor, Sept. 3d, 5th and 17th, 1878.

ANN ARBOR, Sept. 3, 1878.

THE places of the two objects observed by me during the total eclipse of July 29, as communicated in my letter of Aug. 13, were derived from hurried readings of the circles made immediately after my return from the eclipse expedition, in order to be able to answer numerous inquiries addressed to me for more precise information in regard to the observations than had been published in the newspapers. I have since made a more careful determination.

When I came to examine the adjustment of the hour circle to be read upon the reading circle, I noticed that there was a very considerable error of eccentricity, which was shown upon revolving the alidade. Having attended to the adjustment for parallelism of the two circles, I did not attempt to change the eccentricity error, since there would be an error of this kind to be determined in changing the hour circle from the instrument to the reading circle, and since the corrections to be applied on account of the eccentricity can be determined from the four pointings on the sun. I have made ten readings upon each mark, backward and forward, so that each reading is an independent determination, and the results derived from the mean of these readings are shown by the following:

Chronometer Times. By Newcomb's.	Chronometer Times. By Watson's.	Washington Mean Time.	Object Observed.	Circle Reading.
	$4^h\ 3^m\ 50^s$	$5^h\ 7^m\ 31^s$	Sun	$165°\ 31'·6\ \pm 0'·7$
$10^h\ 29^m\ 15^s$		5 16 37	(*a*)	161 1·6 $\pm$ 0·4
10 30 24		5 17 46	(*b*)	156 7·5 $\pm$ 0·5
	4 55 10	5 22 51	Sun	161 38·3 $\pm$ 0·5
	5 4 50	5 32 31	Sun	159 7·0 $\pm$ 0·3
	5 46 55	6 14 36	Sun	148 21·7 $\pm$ 0·7

By comparing the mean of the second and third readings upon the sun with the two extreme readings, I have obtained the following expression for the correction for eccentricity:

$$R_c = R + 103'·7 \sin (R + 63°·2).$$

and hence we derive:

Washington M. T.	Object observed.	Corrected reading.
$5^h\ 7^m\ 31^s$	Sun	$164°\ 13'·7$
5 16 37	(*a*)	159 49·3
5 17 46	(*b*)	155 1·8
5 22 51	Sun	160 25·2
5 32 31	Sun	157 57·2
6 14 36	Sun	147 27·4

These give the following differences in right ascension between (a) and (b) and the sun:

from	(a)—☉ Δα	(b)—☉ Δα
S_1=	$-8^m\ 31{\cdot}6^s$	$-26^m\ 32{\cdot}6^s$
S_2=	−8 37·6	−26 38·2
S_3=	−8 25·6	−26 26·6
S_4=	−8 31·5	−26 32·4

and using the differences of declination as already given, we obtain the following results:

Washington M. T.		Object.	Planet—☉ Δα	Planet—☉ Δδ	Apparent. α	Apparent. δ
	h. m. s.		m. s.		h. m. s.	
1878, July 29.	5 16 37	(a)	− 8 32	−0° 22′	8 27 24	+18° 16′
" 29.	5 17 46	(b)	−26 32	−0 35	8 9 24	+18 3

As already stated in my letter of Aug. 13, there is no uncertainty in the place of (a) beyond the unavoidable instrumental error, which is very small. I saw both it and θ Cancri, and it was fully a magnitude brighter than the latter. In regard to (b) it is possible but not probable that the pointing of the instrument may have been disturbed by the wind. I marked the position on the hour circle first, and but a moment was occupied in passing from the eye piece to the hour circle. I believe that this observation can be relied upon as giving the place of a second intra-mercurial planet.

Ann Arbor, Sept. 5, 1878.

In Professor Young's note upon the recent eclipse published in this Journal, p. 242, he states, in speaking of the discovery of Vulcan, that Professors Newcomb, Wheeler, Holden and others went over the same ground and found nothing, and the inference is made that they obtained negative evidence of some value to dispute the discovery announced. As to the nature of this negative evidence Professor Young is under a mistaken impression.

I happened to be observing near Professor Newcomb and I was informed by him, at the close of the totality of the eclipse, that he had searched north of the sun. Hence he could not see the objects which I observed.

I have seen Professor Holden since his observations were made and he told me that he had been misled in his preparations by having had the idea from the statements of others, who had observed total eclipses, that the illumination of the sky would be very much less than it really was, so that he had observed with optical power insufficient for a search under these circumstances. He used a hand comet-seeker of two and a half inches aperture, with a field of five and a half degrees, and he swept twice over a space thirty degrees in length and

ten degrees in breadth. He did not see any stars until he swept out to Mars and Regulus.

Professor Hall told me that he had searched north of the sun, but that his assistant Mr. Wheeler had searched south. He said, however, that they had been compelled to use a very high magnifying power. Any one who has tried to find so bright an object as Jupiter by attempting to direct the telescope, with a high power, without using the finder, will know how uncertain a search would be under the circumstances named.

As to what was done by other observers I have no direct information. Mr. Swift's account of his work, as published in the New York Tribune, furnishes important corroborative evidence. But the records of my circles cannot be impeached by all the negative evidence in the world. There are no known stars in the places which they give, and hence I cannot be mistaken as to the identity of the objects which I observed.

While referring to the subject of negative evidence, I might as well state here what my own observations give in this respect. Between the limits: Right ascension $8^h 5^m$ to $9^h 5^m$, and declination $+17° 30'$ to $+19°$, I swept once forward and once backward, carefully, and I felt certain that the only objects besides known stars, down to the seventh magnitude inclusive, were the two whose positions I recorded on my circles. I conducted the search expeditiously, but with great care, keeping the motion of the telescope uniform; and if I were to repeat the observations I would not vary the method which I adopted nor undertake to examine a region of greater extent in the same period of time. I cannot conceive of a surer method of recording the position of an object observed, under the circumstances of these observations, without danger of mistake.

ANN ARBOR, Sept. 17, 1878.

Since the letters of Sept. 3d and 5th were written, I have received information from Professor Newcomb, Commander Sampson, U.S.N., and Lieutenant Bowman, U.S.N., who were observing near me, that goes to show that it is highly improbable that there could have been any disturbance of the pointing of my instrument on (*b*), which, for the reasons stated in my letter of August 13, was not verified, in this instance, after the circles had been marked, and which fact it was proper to mention in order that every circumstance connected with these observations might be known to astronomers. My telescope was more completely sheltered than any of the others at the same station, and all three of these observers state that there was no disturbance of their instruments at the time when these observations were made. I find, too, that the direction of the

wind was such that its force, whatever it might have been, was directed almost wholly upon the motion in declination, which was securely clamped. And besides, I have made experiments with the telescope used in the observations, clamped the same as it was then, and I find that it would require a much greater force than if it had been fully exposed to the wind to change the pointing in the least degree sensible.

I have also lately examined (Sept. 15), with the same telescope and magnifying power used in the eclipse observations, the stars in this part of Cancer, with the moon in the western sky and the bright twilight in the east, so as to obtain as nearly as possible the conditions of sky-illumination which existed at the time of the eclipse. I have a very distinct recollection in respect to the brilliancy of the stars which I saw, and by observing when the approaching daylight had reduced the light of certain stars which were east of the sun at the time of the total eclipse, so as to be just visible in the telescope as they were then, I have been enabled to form a still more definite opinion of the relative brilliancy of θ Cancri, the two new objects which I observed, and ζ Cancri. The fainter of the two planets, that near θ Cancri, was certainly brighter than ζ Cancri, and much more than a magnitude brighter than its neighboring star.

ART. XXXVII.—*Letter from Mr. Lewis Swift, relating to the discovery of Intra-Mercurial Planets.* (Communicated to this Journal by Admiral JOHN RODGERS, United States Naval Observatory, Washington, D. C.)

ROCHESTER, N. Y., Aug. 5th, 1878.

BEFORE preparing a report of my observations of the total eclipse of July 29th, as observed at Denver, I hasten to lay before you the facts in detail of my supposed discovery of an intra-Mercurial planet.

Having a comet eye-piece which far surpasses all others that have ever come under my notice, I, before leaving home, decided to devote two minutes of totality to searching for the hypothetical Vulcan. It gives, with my four and a half achromatic, a power of twenty-five, and has a field of 1° 30′, flat and sharp to the edge. About one minute after totality I observed two stars by estimation 3° southwest of the sun, *pointing toward* the sun, of about the fifth magnitude, or what I estimated at the time, as bright through the telescope as Polaris is to the naked eye. How much allowance ought to be made in estimating magnitudes so close to a totally eclipsed

sun, I do not know. I saw them three times, and attempted, at the last moment, to get another observation, but at the critical moment, a little cloud passed over the sun, and I hastened to observe again the sun for the third contact and attending phenomena. At each of the observations, by careful comparison, they appeared exactly of the same magnitude, and both as red as Mars. I looked closely for twinkling, but they were as free from it as the planet Saturn. They both, at the time, seemed to my eye and mind to have a small round disk about like the planet Uranus. Whether the disks were imaginary or real, I cannot tell, but every time I saw them (the stars) the disks attracted my attention. Immediately after totality I recorded the following in my note-book. "Saw two stars about 3° southwest of sun, apparently of the fifth magnitude, some 12′ apart, pointing toward the sun. Both red."

Last evening I experimented with my telescope with the same aperture and eyepiece, to verify or to change my estimate as to distance apart, and I find that they appeared a little farther apart than half the distance between Mizar and Alcor, or, say, about 7′ instead of 10′ or 12′ as estimated at the time. Though at the time I estimated the direction of the stars as southwest of the sun, I am inclined by reflection to change it to south of west.

One of the stars may have been Theta Cancri, and yet there are several chances against a planet being exactly of the same magnitude, color and appearance, as a star; and it appears to me that Theta is most too far north. I would not be surprised, if the truth were known, if both were planets.

Prof. Watson, who claims to have seen a new star 2½° southwest of the sun and of the 4·5 magnitude, may, when he publishes his observations, throw a little light on the subject. Should he have seen the same, of course the priority of discovery belongs to him by about two minutes. That one or both are intra-Mercurial planets, I have no doubt whatever.

It may not be out of place here to say that I was led to the discovery by an accident, the result of carelessness. A strong and fitful breeze was blowing from the southeast which shook my telescope, the equatorial mounting being not very substantial, part of it having been made after reaching Denver. To prevent this shaking, I laid a pole about ten feet in length across the tube near the eye-end, the other resting on the ground to the west of the telescope. Then, for fear it would fall against my head, I tied it to the tube with a string. As I followed the sun, the pole would easily drag along the ground. I intended to remove the pole at the commencement of totality, but in the excitement I forgot it. When I began to sweep along the ecliptic for Vulcan, I found to my horror, that if I

attempted to move the telescope to the east of the sun, the lower end, by plunging into the ground, would prevent me, and I was therefore compelled to devote all my time to the region west of the sun, which accounts for my getting so many views of the objects. From this cause, also, the sweeps were very irregular.

I wish astronomers with large instruments would make the attempt to observe Theta Cancri, before the sun withdraws too far, and if successful then the objects seen by me, we need not despair of their being again observed at some future time without a total eclipse or even in transit.

Let the experiment of detecting a star of the 4·5 or 5 magnitude, and from 2° to 6° from the sun, at a large or annular eclipse, be tried. The result may be to settle this question, and remove all doubt.

Respectfully yours,

LEWIS SWIFT.

Rear Admiral JOHN RODGERS,
Superintendent United States Naval Observatory, Washington, D. C.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Determination of high Melting and Boiling Points.*—CARNELLEY has improved and extended the method for determining high melting points which he proposed in 1876. The method is the usual one for specific heat, the temperature being calculated from the ordinary formula. Two sources of error have now been detected and corrected: one, the excess of heat coming from the suspending wire of the crucible which proved to be large enough to influence the result; and the other, a false water equivalent for the calorimeter. The former error was eliminated by using a finer suspending wire; the latter, by calculating the true value from the formula $MS(T-\theta)=(W+w)(\theta-t)$, in which M the weight of the crucible, S the specific heat of platinum, T the melting point of a salt as determined by a thermometer, t the initial, θ the final temperature, W the weight of water and w the water value of the calorimeter, are all known but the last, several salts whose melting points were accurately known being used in the experiments. In this way 9·8 was fixed as the calorimeter constant. The values obtained after making these corrections, gave melting points entirely trustworthy. The numbers representing these are given in a table, varying from boric acid $B(OH)_3$ 186°, to sodium sulphate Na_2SO_4 861°, and including about a hundred salts.

In connection with WILLIAMS, Carnelley has applied the above results to the determination of high boiling points. Fragments of salts whose melting points are known are placed in the vapor

and examined to see if they melt. Various devices are employed in applying the method, which are described in the paper. In the case of $HgCl_2$ for example, $NaClO_3$ melts in its vapor while $NaNO_3$ does not; hence its boiling point is between 302° and 316°. Observation with a thermometer gives it as 303°. Anthracene vapor fuses KNO_3 but not $KClO_3$, hence its boiling point is between 339° and 359°. Thallous iodide TlI, boiling, melts NaCl and $Pb(PO_3)_2$ but not PbP_2O_7 or Na_2CO_3; its boiling point is therefore between 800° and 806°. The authors hope shortly to be able to fix the boiling points of K, Na, Mg, Tl, etc., in this way.—*Jour. Chem. Soc.*, xxxiii, 273, 281, July, 1878. G. F. B.

2. *On the Vapor Density of Thallous chloride and Lead chloride.*—Roscoe has simplified Deville and Troost's method of vapor density, desiring only to give it sufficient accuracy to fix molecular weights. A long-necked porcelain globe, of about 300 c.c. capacity, containing from 3 to 9 grams of the substance to be examined, is loosely closed with a stopper of burned clay and placed in a muffle until no more vapors escape and the temperature is constant. The globe is then removed, allowed to cool and the amount of substance it contains is determined by analysis. The temperature of the muffle is fixed calorimetrically by placing in it at the same time a weight of platinum of known value. It may be checked by the use of a second balloon containing mercury. In five consecutive experiments with mercury, the temperatures being 1019°, 894°, 815°, 972° and 1047°, the vapor-density of mercury vapor was found to be 6·92, 6·75, 6·91, 5·77, and 7·05; or 6·68 as a mean. In the case of thallous chloride seven experiments, at temperatures of 859°, 828°, 1015°, 849°, 1026°, 852° and 837°, gave 8·15, 8·28, 8·06, 7·43, 8·75, 8·60 and 7·84 as the density of its vapor. The calculated value, assuming the molecular weight to be 238·07 and the formula TlCl, is 8·49. The vapor density of lead chloride determined in this way, requiring however a higher temperature, was 9·12, 9·72, 9·51 and 9·64, at 1046°, 1089°, 1077° and 1070° respectively, the theoretical value for $PbCl_2$ with a molecular weight of 277·14, being 9·62.—*Ber. Berl. Chem. Ges.*, xi, 1196, June, 1878. G. F. B.

3. *On the Action of Steam on ignited Charcoal.*—Long has made a series of experiments under the direction of Lothar Meyer, to ascertain whether the carbon dioxide produced by the action of steam on ignited wood charcoal stands in any fixed relation to the carbonous oxide. The charcoal was purified by treatment with boiling nitric and hydrochloric acids, and thorough washing, a porcelain tube 60 cm. long was filled with it, placed in a furnace, heated to redness and steam driven through it, the gas evolved being collected over water, and analyzed by Bunsen's method. In the first series of experiments, the results were not uniform for successive portions of gas, the CO_2 increasing and the CO diminishing. Moreover, two volumes of hydrogen should appear for every volume of CO_2 and one for each volume of CO; but this was not the case, the hydrogen being always too low. These

results being confirmed by a second series of experiments, the author made direct tests to see if this error was due to an actual loss of hydrogen or to an introduction from without of carbon dioxide. On filling the tube with charcoal, displacing the air with hydrogen, closing one end, attaching a potash apparatus to the other and heating, 250 c. c. of CO_2 were collected in two hours. Hence the discrepancy in the analyses arises from absorbed gases in the charcoal, either CO_2 directly or free oxygen, and diminishes as the operation continues. Making allowance for this excess, no simple relation appears between the two oxides of carbon. The amount of carbonous oxide formed, however, appears to be determined by the amount of charcoal present, diminishing steadily as this lessens. This can only be explained by supposing that the first action of the steam upon the coal is to produce carbon dioxide, and that this, by the further action of the coal, is reduced in part to carbonous oxide, in precise analogy with the ordinary action of oxygen upon carbon. If the carbonous oxide be in contact with an excess of steam, a reduction of the steam takes place. $CO+H_2O=CO_2+H_2$. In practice, probably all three of these reactions go on simultaneously, the relative quantities of steam and charcoal determining the proportion of the gaseous constituents.—*Liebig's Ann.*, cxcii, 288, June, 1878.

G. F. B.

4. *On the Reduction-product of Gum Elemi by Zinc-dust.*—CIAMICIAN has continued his reduction experiments with the gum-resins and has now submitted gum elemi to the action of zinc-dust. Commercial gum elemi was treated first with cold alcohol, and the residue of this operation was recrystallized from hot alcohol, and obtained in long needles in wavellite-like groups. The reduction was effected as in the case of abietic acid, the vapors being passed over ignited zinc dust. From 800 grams of the crystallized gum 300 c. c. of a brown oil, lighter than water, was obtained. Distillation in steam gave a volatile portion (A) and a tarry portion (B). The former, after boiling with sodium, was fractionated. Two products resulted, one boiling at 111° and easily recognized as toluene; the other boiling at 158°–160°, a colorless oil of peculiar aromatic odor, was evidently ethylmethylbenzene. The first gave benzoic acid on oxidation, the latter a mixture of isophthalic and terephthalic acids. Hence both para- and meta-ethylmethylbenzene were present in this latter fraction. Portion B afforded after treatment, a colorless liquid, boiling between 250° and 252°, having an aromatic odor resembling that of naphthalene, and a specific gravity near that of water. Analysis and its oxidation products fixed it as ethylnapthalene. Hence toluene, meta-ethylmethylbenzene, para-ethylmethylbenzene, and ethyl-naphthalene are the products of the reduction of gum elemi by zinc dust.—*Ber. Berl. Chem. Ges.*, xi, 1344, July, 1878.

G. F. B.

5. *On the Constitution of Starch.*—MUSCULUS and GRUBER have made further experiments in support of the view advanced

by the former of these chemists, that the saccharification of starch by diastase or dilute acids, should be considered a splitting into a dextrin and sugar simultaneously. They now find that the action of the above agents on starch produces: 1st, soluble starch, soluble in water at 50°–60°, colored wine-red by iodine when in solution, blue when dry, rotatory power $[\alpha]=+218$, reducing power $=6$; 2d, erythrodextrin, soluble in cold water, colored red by iodine, both in solution and solid, easily attacked by diastase; 3d, achroödextrin α, not colored by iodine, rotatory power $[\alpha]=+210$, reducing power $=12$, partially saccharifiable by diastase; 4th, achroödextrin β, rotatory power $[\alpha]=+190$, reducing power $=12$, unacted on by diastase in 24 hours; 5th, achroödextrin γ, rotatory power $[\alpha]=+150$, reducing power $=28$, unattackable by diastase, converted into glucose by sulphuric acid only after long boiling; 6th, maltose, formula $C_{12}H_{22}O_{11}.H_2O$, rotatory power $[\alpha]=+150$, reducing power $=66$, unacted on by diastase, but fermentable; 7th, glucose, $C_6H_{12}O_6.H_2O$, rotatory power $[\alpha]=+57$, reducing power $=100$, fermentable. The authors hence consider starch as $(C_{12}H_{20}O_{10})_n$, in which the exact value of n, which cannot be less than five or six, is yet to be determined. Under the influence of ferments or of dilute acids, it undergoes a series of hydrations and successive splittings, forming at each, maltose and a new dextrin having a less molecular weight. The value of n becomes less and less until the γ form of achroödextrin is reached, which is transformed by simple hydration directly into maltose, which again splits into glucose.—*Bull. Soc. Chim.*, II, xxx, 54, July, 1878. G. F. B.

6. *Synthesis of Indigo-blue.*—Early in the present year, BAEYER showed that oxindol was identical with orthoamidophenylacetic acid, and hence had the formula $C_6H_4\left\{\begin{matrix}CH_2CO\\NH—|\end{matrix}\right.$. In order to produce isatin synthetically from this, it is only necessary to reverse the process by which oxindol is produced from isatin; *i. e.*, to convert the CH_2 group in the above formula into CO. This the author has now succeeded in doing, not by direct but by indirect oxidation. From nitrosoöxindol $C_6H_4\left\{\begin{matrix}CH(NO)CO\\NH———|\end{matrix}\right.$ which contains the nitrosyl group in the right position, amidoöxindol $C_6H_4\left\{\begin{matrix}CH(NH_2)CO\\NH———|\end{matrix}\right.$ is produced by reduction, and from this by oxidation with ferric or cupric chloride or even with nitrous acid, isatin $C_6H_4\left\{\begin{matrix}COCO\\NH—|\end{matrix}\right.$ is produced. The reduction of this to indigo-blue, effected long since by the author in conjunction with Emmerling, by the action of phosphorous chloride, acetyl chloride and phosphorus, he now finds to take place in two stages. In the first, produced by the action of phosphoric chloride upon isatin, an imidchloride of isatin results, $C_6H_4\left\{\begin{matrix}COCCl\\N=\!=\!=||\end{matrix}\right.$. This, by reduction with phosphorus, zinc dust, or preferably with ammonium sul-

phide, gives flocks of indigo blue.—*Ber. Berl. Chem. Ges.*, xi, 1228, 1296, June, July, 1878. G. F. B.

7. *On Anthrarufin, a third Dioxyanthraquinone.*—SCHUNCK and ROEMER have shown that when concentrated sulphuric acid acts on metaoxybenzoic acid, two products are formed, the one soluble, the other insoluble in water. From the latter two other substances may be derived, the one soluble in barium hydrate, the other insoluble therein. The former of these bodies consists, as the authors have already shown, of two dioxyanthraquinones, anthraflavic acid and metabenzdioxyanthraquinone. They now show that the substance insoluble in barium hydrate contains a third dioxyanthraquinone, to which they give the name anthrarufin. The product of the reaction of sulphuric and oxybenzoic acids is thoroughly extracted with water and barium hydrate. A brownish-black powder results from which the new isomer of alizarin may be prepared by taking advantage of its volatility. Placing the powder between two watch glasses, and heating these to 120°–130°, an orange-yellow sublimate is obtained in needles. Recrystallization from glacial acetic acid gives it pure. Anthrarufin fuses at 280°, is difficultly soluble in alcohol with a yellow color, crystallizes in yellow quadratic iridescent tables, and is soluble in concentrated sulphuric acid, the solution being cherry red in transmitted and kermes red in reflected light. Dilute solutions show two sharp absorption spectral bands, and a third weaker. One part in ten million of sulphuric acid shows a carmine red color in a layer an inch thick, minute quantities of nitric acid change the color to an intense yellow. Potassium hydrate dissolves it to an olive-yellow color. Insoluble in sodium carbonate, and yields a green fluorescent reduction product. Gives with acetic oxide a diacetyl derivative in yellow needles, fusing at 245°.—*Ber. Berl. Chem. Ges.*, xi, 1176, June, 1878. G. F. B.

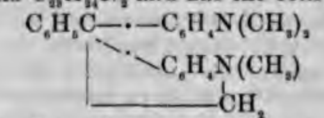
8. *On a Fluorescein-carbonic acid.*—The remarkable bodies discovered by Baeyer, the phthaleins of the phenols, have their origin in the great facility with which phthalic acid becomes an anhydride, and hence combines easily with hydroxylbenzenes. SCHREDER has sought to ascertain whether acids with neighboring carboxyls, such as trimellitic acid, which has the position 1 : 2 : 3, would not act similarly, retaining however, the carboxyl group. For this purpose, a quantity of trimellitic acid was heated to 200° with resorcin, and yielded a substance resembling fluorescein, but containing a carboxyl group; to which consequently the author gives the name fluorescein-carbonic acid. It has the formula

$$C_6H_3\left\{\begin{array}{l}CO{-}\cdot{-}C_6H_3\\CO{-}\cdot{-}C_6H_3\\COOH\end{array}\right.\left\{\begin{array}{l}OH\\O\\OH\end{array}\right.$$

and appears as a light ochre-yellow powder, scarcely soluble in water but soluble in alcohol, ether and benzene. The barium and calcium salts were prepared, and also acetyl, dibrom and tetrabrom-derivatives.—*Ber. Berl. Chem. Ges.*, xi, 1340, July, 1878.

G. F. B.

9. *On New Coloring Matters, as Malachite green.*—DOEBNER sometime ago showed that the synthesis of aromatic oxyketones could be effected by acting on the benzoic ether of a phenol, either with benzoyl chloride and zinc chloride, or with benzotrichloride and zinc oxide; there being produced in both cases the body $C_6H_5CO.C_6H_4OCOC_6H_5$, from which by saponification benzoylphenol $C_6H_5CO.C_6H_4OH$ resulted. If now in place of the ether, the phenol itself be employed, and it be heated with benzoyl chloride in presence of dehydrating substances, coloring matters are produced. The effect, however, is much greater if tertiary aromatic bases are employed in place of the phenols, magnificent green coloring matters being produced. One of these has already been introduced for some time into commerce, prepared by the action of benzo-trichloride upon dimethylaniline, and known under the name of malachite green. It affords on analysis the formula $C_{23}H_{24}N_2$ and has the constitution



—*Ber. Berl. Chem. Ges.*, xi, 1236, June, 1878. G. F. B.

10. *Electrolytic methods of determining lead, copper, zinc and nickel.*—In the Annales de Chemie et de Physique for April, M. Alfred Riche describes electrolytic methods for the separation and estimation of lead, copper, nickel and zinc. The conditions of success in these determinations have been carefully studied, and the large experience of M. Riche in the analysis of alloys renders the paper particularly valuable to the analytical chemist. There is little, however, which is especially new in his methods, and he has entirely overlooked the work of American chemists in the same field. J. P. C., JR.

11. *Alcoholic Fermentation.*—In the same number of the above journal, M. A. Müntz gives an interesting account of numerous experiments, which tend to show that alcoholic fermentation takes place in the cells of all plants when confined in an atmosphere deprived of oxygen gas. The experiments were made on such common plants as beets, maize, geranium, cabbage, portulaca and chicory, growing in pots in a natural condition, and it is stated that alcohol could be invariably detected in different parts of these plants after several hours' exposure in an atmosphere of nitrogen, although no trace of alcohol could be discovered in other plants of the same growth not thus treated. The growing plants were covered by a glass bell standing in a pan holding an alkaline solution of pyrogallic acid, which in the course of twenty-four hours absorbed all the oxygen and carbonic dioxide of the confined air, leaving an atmosphere of nearly pure nitrogen. In this atmosphere the plants were left for from twelve to twenty-four hours longer, without impairing the vitality of the plant, as the continued growth of duplicate plants similarly exposed abundantly proved. The tissue of the plant was then

bruised with water and alcohol proved to exist in the distillate from this emulsion by the production of the characteristic crystals of iodoform after the addition of sodic carbonate and iodine in a manner which is fully described. These results are interesting as confirming the views of Pasteur that the alcoholic fermentation produced by ordinary yeast is simply an exaggeration of the normal action of all organic cells in an atmosphere or medium devoid of oxygen. J. P. C., JR.

12. *Vapor of Chloral Hydrate.*—The specific gravity of the vapor of chloral 74·04 (referred to hydrogen) corresponds to the molecular structure of the compound as indicated by its chemical relations and represented by the formula $CCl_3-CH{=}(HO)_2$ $CCl_3-CH{=}O$; but the vapor of chloral hydrate has only one-half of the specific gravity (39·84) which the law of Avogadro would require. Hence it has been generally supposed that in volatilizing, the hydrate was resolved into chloral and water. Assuming that this vapor is a simple mixture of chloral vapor and aqueous vapor each independent,—the mixture having a tension equal to the sum of the tensions of the constituents,—then we should infer that if a material susceptible of hydration were introduced into the vapor the effect would be similar to that obtained by introducing the same substance into any inert atmosphere saturated with aqueous vapor at the same temperature. On the other hand, if the vapor of chloral hydrate is a homogeneous gas consisting solely of molecules having the constitution represented above, then if we introduced a hydrous salt into this vapor we should anticipate that this salt would effloresce, thus giving off more or less of its water, just as it would in any other dry and inert atmosphere under like conditions. These well known principles offer an obvious method of testing the condition of the vapor of chloral hydrate which has been applied by M. L. Troost in an article published in the Annales de Chimie et de Physique for March. In his experiments, M. Troost volatilized the chloral hydrate in the Torricelian vacuum of Hofmann, apparatus for determining the density of vapors, and introduced into the vapor potassic oxalate, both in its hydrous and its anhydrous condition. The apparatus was slightly modified to suit the conditions and potassic oxalate was chosen as the reagent because its affinity for water—as shown by the quantity of heat evolved during combination—is less than that of chloral. Lastly, any effect which the reagent produced on the vapor was indicated by the change of tension. But for these and all other details we must refer to the paper. From these experiments, M. Troost deduces the conclusion that neither at 78° C. nor at 100° C. are the constituents disassociated, at least to any great extent, in the vapor of chloral hydrate; that the vapor of this substance is perfectly homogeneous and normally occupies twice the volume which the law of Avogadro requires. Hence M. Troost would have us infer that this law, as the basis of modern chemical philosophy, has failed.

As the writer has before said in these pages, the law of Avogadro is simply a mode of correlating facts, and its value as a scientific theory rests on the degree of certainty with which it points the way to new discoveries. As soon as it begins to lead astray it will doubtless be abandoned, like many another philosophical guide before it. In order to invalidate the theory it is not enough to adduce unexplained facts; it is essential to show that phenomena which have been fully investigated are inconsistent with it. In the present instance the experiments of M. Troost undoubtedly seem to indicate that the vapor of chloral hydrate does not contain aqueous vapor as such, for although the results are not as sharp as might be desired yet the difference in the action before and after additional water had been mixed with the vapor of the hydrate seems to be conclusive on this point. But nevertheless, before we can admit that the vapor of chloral hydrate contains only one-half as many molecules in the same volume as the vapor of chloral, it must be proved that the molecules of the hydrate, when in the state of vapor, have all the chemical constitution represented by the usual symbol as given above, and not only is no direct evidence offered on this point but the presumption is wholly against such a conclusion. J. P. C., JR.

13. *Solubility of Lime in Water.*—The fact that lime is more soluble in cold than in hot water was first observed by Dalton in 1808, and his observations were confirmed by R. Phillips in 1821. Very recently the relative solubility of lime in water at different temperatures has been very carefully studied by M. A. Lamy. This French chemist finds that the solubility varies to a marked extent with the state of aggregation of the lime, with the material from which it was prepared, as well as with the temperature to which it was heated in the process, with the time during which it is left in contact with water and with various other circumstances, some of which produce a permanent and others a transient effect. It is undoubtedly the influence of such causes of variation, previously unknown, that led both Dalton and Phillips to somewhat erroneous results, although they accurately observed the general order of the phenomena. We must refer to the original paper in the Annales de Chemie et Physique, June, 1878, for the details. The following table, however, numbered XV, in the article referred to, will give a general idea of the results:

Temperature.	Lime from carbonate precipitated from nitrate with ammonic carbonate.	Lime from marble several times washed.	The same lime after slacking and again igniting.
0°	1·362 grams.	1·377 grams.	1·430 grams.
10°	1·309 "	1·328 "	1·384 "
15°	1·279 "	1·295 "	1·345 "
30°	1·142 "	1·158 "	1·195 "
45°	0·985 "	1·005 "	1·033 "
60°	0·841 "	0·864 "	0·885 "
100°	0·56 "	0·575 "	0·585 "

In each case the numbers indicate the weight of lime contained in 1000 grams of the solution, and we have selected this table from several others in the paper because as the author says the values

are comparable, having been obtained under similar conditions. The other series of results which are given do not differ greatly from the above, the differences appearing at most in the third significant figure. The several curves of solubility which are plotted with these different series are nearly parallel, and all show a region of contrary flexure between fifteen and forty-five degrees.

J. P. C., JR.

14. *Oxygen in Metallic Silver.*—It has long been known that melted silver dissolves quite a large volume of oxygen gas, but M. Dumas has recently shown that the metal in its ordinary state may contain a notable amount of the same substance. When reduced from the chloride with the usual fluxes and granulated, one kilogram of the metal may contain 249 milligrams of oxygen. This impurity may have determined a sensible error in the values of the atomic weights referred to silver, and Dumas suggests that the differences between the precise results obtained with so much labor by Stas, and the exact multiples of the atomic weight of hydrogen accepted by himself, may be due to this cause. Such facts as the one here presented tend to greatly strengthen the opinion expressed by the writer in a recent paper on the atomic weight of antimony: that the errors chiefly to be feared in the determination of atomic weights are not such as can be eliminated by the repetitions of the same process, but constant errors which arise from our want of precise knowledge of all the conditions under which the determinations are made, and that in the present state of science no certain conclusions can be reached in regard to the validity of Prout's law or of other numerical relations between the atomic weight of the chemical elements. J. P. C., JR.

II. GEOLOGY AND MINERALOGY.

1. *Occurrence of Fossiliferous Tertiary Rocks on the Grand Bank and George's Bank;* by A. E. VERRILL.—Among the most important results of the investigations made by the party connected with the U. S. Fish Commission, stationed at Gloucester, Mass., during the present season, is the discovery of fragments of a hitherto unknown geological formation, apparently of great extent, belonging probably to the Miocene or later Tertiary. The evidence consists of numerous large fragments of eroded, but hard, compact, calcareous sandstone and arenaceous limestone, usually perforated by the burrows of *Saxicava rugosa*, and containing in more or less abundance fossil shells, fragments of lignite, and in one case a spatangoid sea-urchin. Probably nearly one-half of the species are northern forms, still living on the New England coast, while many others are unknown upon our coasts and are apparently, for the most part, extinct. From George's Bank about a dozen fossiliferous fragments have been obtained, containing more than twenty-five distinct species of shells. Among these one of the most abundant is a large thick bivalve (*Isocardia*) much resembling *Cyprina Islandica* in form, but differing in the struct-

ure of the hinge. This is not known living. *Mya truncata*, *Ensatella Americana*, and the genuine *Cyprina* are also common, together with a large *Natica*, a *Cyclocardia* (or *Venericardia*) allied to *C. borealis* (Con.), but with smaller ribs, *Cardium Islandicum*, and also various other less common forms. These fragments came from various parts of the bank, including the central part, in depths varying from 35 to 70 fathoms, or more.

From Banquereau, N. S., we received one specimen of similar rock, containing abundant fragments of a large bivalve, and about a dozen other species, among which are *Fusus* (*Chrysodomus*) *decemcostatus*, *Latirus albus* Jeff. (?), unknown species of *Turritella*, etc. From the Grand Bank two similar specimens were received. One of these, from thirty-five fathoms, lat. 44° 30′, long. 50° 15′, contained numerous specimens of *Cyprina Islandica* in good preservation.

In gathering these specimens from the fishermen and working out the specimens, Mr. W. Upham has been very active. It will probably be possible hereafter, when these specimens shall have been more fully examined, and more obtained, to give a pretty long list of species, especially from George's Bank.

At present it appears probable that these fragments have been detached from a very extensive submerged Tertiary formation, at least several hundreds of miles in length, extending along the outer banks, from off Newfoundland nearly to Cape Cod, and perhaps constituting, in large part, the solid foundations of these remarkable submarine elevations.

2. *On Liquid Carbonic acid in Syenite;* by Mr. G. W. HAWES. (From Mr. Hawes' New Hampshire Geological Report.)—The presence of liquid carbonic acid in the microscopic cavities that exist in the quartz of granites having been often observed, I carefully searched for it in the sections of the New Hampshire rocks. Although the number of sections was large, yet in no case was I able to find it in any of the granitic rocks, except in a syenite from Columbia, and here it occurred in the greatest abundance, and under circumstances that render its occurrence interesting.

The syenite referred to is white in color, spotted with black, and macroscopically only orthoclase and hornblende are recognizable. In thin sections, however, plagioclase, biotite, quartz and apatite are seen, and moreover calcite is found; a mineral which rarely occurs in granitic rocks. The quartz is present only in small amount, occupying angular corners between the other constituents, but every grain of it is filled with cavities, which are quite large, and many of them contain liquid carbonic acid. Its presence in connection with the calcite may indicate that calcium carbonate was a constituent of the sedimentary material from which this rock was made, and that at the temperature at which crystallization took place, a reaction occurred between the silica and the carbonate resulting in the liberation of carbonic acid.

III. BOTANY AND ZOOLOGY.

1. *Monographiæ Phanerogamarum Prodromi nunc continuatio, nunc revisio*, auctoribus ALPHONSO et CASIMIR DECANDOLLE, aliisque Botanicis ultra memoratis. Vol. I, *Smilaceæ*, *Restiaceæ*, *Meliaceæ*, cum tabulis ix. Paris, Masson. June, 1878. pp. 779, roy. 8vo.—In this form and way we may hope to see the Monocotyledonous orders elaborated, and some of the earlier Dicotyledonous ones re-elaborated. The middle of this volume is filled by the monograph of *Restiaceæ*, by Dr. Masters. This is an order allied on the one hand to *Juncaceæ*, on the other to *Cyperaceæ*, of twenty genera and two hundred and thirty-four species, wholly of the southern hemisphere, divided between South Africa (which has much the larger share) and Australia with New Zealand, and a single species in Chili. It is not a prepossessing family, and presents peculiar difficulties to the systematist, on account of the diœcious character of most of them, and a striking difference between the plants of the two sexes, which in collections are hard to match. Much praise is due to Dr. Masters for his great labor, patience and skill. The latter half of the volume is occupied by Casimir DeCandolle with his neat revision of the *Meliaceæ*, chiefly a tropical order. The stamineal tube in the monadelphous *Meliaceæ* is concluded to be a staminiferous disk. The *Smilaceæ* by Alphonse DeCandolle form the smaller but to us the most interesting part of the volume.

This order is restricted to three genera; two of them diœcious, *Heterosmilax* with united sepals, no petals, and three monadelphous stamens (East Asiatic), *Smilax* with separate sepals, petals, and (6–15) stamens; the third, *Rhipogonum* (of New Zealand and Australia), with hermaphrodite flowers. Of *Smilax* one hundred and eighty-six species are characterized, and a dozen or two more are obscure or doubtful. There are thirty-eight pages of prefatory *generalia*, in DeCandolle's best manner. We are pleased to find that he keeps up the *specific phrase*, and with true Linnæan curtness, relegating all particulars, not truly diagnostic under the sections and other divisions, to the description. In discussing the nature and characters of the leaf (which in its general sense is called "récentement et assez inutilement *phyllome*") the morphology of the petiolar tendrils has to be considered; the conclusion is that these answer rather to leaflets than to stipules, and the articulation, in some species well marked, between the blade and the petiole, or in the petiole, is noted as supplying good specific characters, which have been overlooked. The umbels are centrifugal or cymose. To distinguish, as is here done, the perianth into sepals and petals and to use these names when practicable, is most proper; but it hardly follows that the term perianth or perigone will then have no *raison d'être*. Whatever the number and position of the stamens, the carpels are superposed to the sepals, as indeed is the case in most Monocotyledons. It is perti-

nently noted that in *Smilax*, always diœcious, and with dull-colored perianth, the pollen is papillose as in most entomophilous flowers; but that *Rhipogonum*, the only hermaphrodite genus, has a smoothish pollen, more like that transportable by the winds. Most have odorous blossoms, some pleasantly, some the reverse. DeCandolle asks whether in our *Coprosmanthus* (the name of which indicates the ill odor) this is common to both sexes and the same in both. Can any of our readers speak to this? An exposition of the geographical distribution of the order, and of what is known of it in a fossil state, is followed by a statement that all the four natural sections of *Smilax* and the two other genera—i. e. all the types of the order—co-exist in the comparatively small area comprised between the north of New Holland, the Figi Islands, the Sandwich Islands, and Japan; that India has four of these six types, New Holland three, North America two, all Europe and Africa one; South America only one, but is rich in species. The speculative inference is, that, anterior to the eocene formations of Europe, the ancestors of the family occupied a continent situated in the region above indicated, of which the most ancient form was probably monœcious, gamosepalous, apetalous, monadelphous, and with more or less volatile pollen,—in short was like *Heterosmilax*,—that this ancestor was in that region diversified, giving origin to the five other groups, beginning with *Eusmilax*, the widest diffused and most numerous in species, and finishing with *Rhipogonum*, which with *Heterosmilax* has clung to its birthplace. The sole Californian *Smilax* is referred, as a variety, to *S. rotundifolia*, but is nearer *S. hispida*, although distinct from both. A. G.

2. *The Flora of British India*, by Sir J. D. HOOKER, K.C.S.I., President R. S., etc., assisted by various botanists, makes fair progress. Part V, the second part of the second volume (pp. 241–496) is before us, undated. In it the *Leguminosæ* by Baker are finished, the *Rosaceæ* elaborated by Dr. Hooker himself, the *Saxifragaceæ* and succeeding orders up to *Halorageæ* by C. B. Clarke, the *Rhizophoreæ* by the Rev. G. Henslow, *Combretaceæ* by Mr. Clarke, and finally the *Myrtaceæ* by a new hand, J. F. Duthie, F.L.S. For the section of *Potentilla* of which *P. fruticosa* is the type, the name *Trichothalamus* is coined, a better one than *Comocarpa* in Torr. & Gray, Flora. *Eriobotrya* is kept up as a genus, as are Decaisne's *Docynia* and *Pourthiæa*. A. G.

3. *Blüthendiagramme* [*Flower-diagrams*] *construirt und erläutert*, von Dr. A. W. EICHLER, Professor Bot. Univ. Kiel.—The first part, of 348 pages, 8vo, and 176 wood-cuts, was published in 1875, (Leipzig, W. Engelmann). It was devoted to the Gymnosperms, Monocotyledons, and the Sympetalous* (Gamopetalous) Dicotyledons. The second was issued in the spring of the present year, on the eve of the author's removal to Berlin, to occupy the botanical chair vacated by the death of Braun. It deals with the Apetalous and Choripetalous [Polypetalous] Dicotyledons,

* We take a fancy to this name *Sympetalæ;* but Gamopetalæ is older and in common use.

intercalated into one class; it fills 575 pages and is illustrated by 237 wood-cuts. We had deferred notice of this admirable work until it should be completed. This has now happily been done; but we are unable at the present moment to prepare the detailed review which such a useful, conscientious, and able contribution to morphological botany should have. Being a work specially adapted to instruction, it ought to be translated into English; but we fear this may not just now be done, as morphology is not sufficiently appreciated. The brief introduction first explains Flower-diagrams, the mode of constructing them, and the purpose they subserve; then, some general remarks on the nature or definition of the flower, its development, and its parts, precede a brief discussion of the arrangement of the floral organs, the relation of the blossom as a whole and of its outer members to bract and bractlets; and finally inflorescence is considered, with principal reference to the terminology and classification of the cymose type. Some notes succeed on the morphology of ovula, placenta, stamina, etc. And in the preface to the second part a few pages are devoted to similar topics;—to the spiral theory of the flower-organs and the nature of placenta and ovula (the author frankly modifying his former views in consequence of the later researches of others), to Obdiplostemony (the production of the first rank of stamens opposed to petals), which is in some sort a re-discussion of outgrowths and intercalary leaves, as treated in notes to the first volume. These discussions, and the presentations by diagrams and otherwise of the particular morphology of the natural orders in systematic sequence, mark this work as one of the first importance. A. G.

4. *Repertorium Annuum Literaturæ Periodicæ*, cur. G. Bohnensieg et W. Burck. Tom. iv, for 1875. Harlaem, 1878. 283 pp. 8vo.—Having noticed the preceding volumes, we would renew the expression of admiration for the careful and thorough manner in which this work is planned and executed. The classification of topics is very detailed and special; and there is a full index of names of genera and orders, and another of authors. A. G.

5. *Synopsis of the Genus Aquilegia*, by J. G. Baker.—A contribution to the Gardener's Chronicle, London, concluded in the number for August 17, 1878; intended specially for horticultural use, but also of botanical consequence, arranging under artificial groups and describing in a plain way twenty-seven species. A northern Rocky Mountain Columbine, *A. Jonesii* of Dr. Parry, appears not to be known to the writer. It is rather strange that *A. chrysantha* and *A. cœrulea* (of which Mr. Baker seems to know only the almost white form) should fall under different sections, even when these are founded on size of flower; but this comes from the sepals only giving the measure. *A. truncata*, the Californian species, is quite distinct from *A. formosa* (which grows farther north and east), and is handsomer in cultivation. When the characters are once apprehended, either in live or dried specimens, there will be no need of again confusing them. A. G.

6. *Note on the Reëstablishment of Forests in Iowa now in progress;* by Prof. C. A. White. (Communicated.)—In the admirable lecture on Forest Geography and Archæology by Professor Asa Gray, published in the August and September numbers of this Journal there is a single passing allusion or hypothetical statement which I think involves an error. I refer to the two closing sentences on page 94 of the August number which read thus: "The difficulty of re-foresting bleak New England coasts, which were originally well wooded, is well known. It is equally, but probably not more difficult to establish forest on an Iowa prairie with proper selection of trees." It is plain that Professor Gray intended in those sentences to state the difficulty of re-foresting only hypothetically in order to meet the question, "Why have the trees not grown where they might have done, and grown again where they have been destroyed?"; and in the preceding paragraph on the same page he had given a correct and concise statement of the true arboreal status of Iowa.

In view of the grand facts and generalizations presented in that lecture the objection here raised is very insignificant, but the statement referred to involves a question which to the people of Iowa is of the greatest economic importance, and this is my only reason for calling attention to it. In vol. i, pp. 129–132 I have given a statement of the results of many years observations in Iowa and adjoining States of which the following is the substance.

All varieties of forest trees that are indigenous to that region will grow thriftily upon all varieties of its soil, when transplanted or propagated from the seed. Wherever the annual fires have been prevented, and no effort has been made to prevent the growth of forest trees, they have rapidly taken possession of originally prairie surfaces and changed them to dense forests. The forest area of Iowa has been increasing ever since its first settlement by white men, even beyond the amount consumed, and it is rapidly increasing to-day, both by natural growth and artificial propagation. The latter may be so readily accomplished that an Iowa farmer grows his forest with the same certainty and facility that he does his corn and wheat. I do not intend to discuss the question why these facts exist; I only state them as I know them; but the following words by Professor Gray upon this point strike me as not only sagacious, but strictly true. "I am disposed, on general considerations, to think that the line of demarkation between our woods and our plains is not where it was drawn by nature. . . . . . I suspect that the irregular border line may have . . . been rendered more irregular, and have been carried further eastward wherever nature of soil or circumstances of exposure predisposed to it."

7. *Entomological Contributions*, No. IV; by J. A. Lintner. (Printed in advance from the Thirtieth Annual Report on the New York State Museum.) 144 pp. 8vo. Albany, June, 1878.—A series of twenty-seven separate papers, of which the first three are upon a "hair-worm" (*Mermis acuminata*) parasitic on the apple-worm larva, the new carpet-bug, and the grape-seed fly.

All the other papers are upon Lepidoptera, principally of New York State, including descriptions of new species, notes on habits, capture, etc., and also a systematic arrangement of the European and some American Hesperidæ, partially from manuscript and partially from a publication of Dr. Speyer of Prussia. S. I. S.

IV. Astronomy.

1. *Observation of the new planet* (189); by C. H. F. Peters. (From a letter to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Sept. 18, 1878.)—The following is an observation made last night of a planet, that probably will receive the number 189 of the asteroid group:

1878.	Ham. Coll. m. t.	A. R. app.	Decl. app.
Sept. 17	$13^h\ 12^m\ 52^s$	$1^h\ 9^m\ 45^s{\cdot}28$	$+9°\ 38'\ 18''{\cdot}2$

from 15 filar micrometer comparisons with the star Rümker II. 568.

I had already become aware of this planet on the night of Sept. 9–10, at about four o'clock in the morning, when daybreak did not give time for a regular measurement. For several days thereafter the strong moonlight interfered. From the position as put down in my chart, I derive the place, reduced to 1878·0:

$$\alpha = 1^h\ 14^m\ 2^s;\ \delta = +10°\ 19'{\cdot}7,$$

whence in combination with last night's observation follow the daily motions -33^s and $-5'{\cdot}2$ about.

The magnitude of the planet I estimated at 11, and it was as well visible with the light of the moon as it now is.

2. *Annals of the Harvard College Observatory.*—Two more volumes of Annals have just been distributed from the Harvard College Astronomical Observatory. One is the second part of Vol. IV, containing observations made in 1862–5 on the right ascensions of 505 principal stars, and is edited by Professor T. H. Safford. The other is Vol. IX, and is written by Professor C. S. Peirce, of the Coast Survey. It consists of five chapters, whose titles indicate the ground covered by the author: (1) The Sensation of light; (2) The numbers of stars of different degrees of brightness; (3) Original observations; (4) Comparisons of the different observers; (5) The form of the galactic cluster. The observations were made with a Zöllner astrophotometer, under the general direction of Professor Winlock. They were begun at Cambridge, and continued at Washington and elsewhere, as the author's duties in the Coast Survey made changes of residence necessary. The work is also published separately by Engelmann, Leipzig, under the title *Photometric Researches.*

V. Miscellaneous Scientific Intelligence.

1. *American Association.*—The twenty-seventh meeting of the American Association for the Advancement of Science convened at St. Louis, Missouri, on Wednesday, August 21st, and continued for one week. The President of the meeting was

Professor O. C. MARSH, and the Vice-Presidents R. H. THURSTON, of Hoboken, and A. R. GROTE, of Buffalo. The meeting was a successful one, although the attendance was not so large as usual, owing to the extreme heat and the fear of the yellow fever.

The local committee consisted of Chancellor W. G. ELIOT, Judge CHARLES SPECK, Professor J. K. REES, GEORGE BAIN, WM. TAUSSIG, W. H. PULSIFER, Dr. GEORGE J. ENGELMANN and others, who made most satisfactory arrangements for the entertainment of the members, and for the sessions of the Association.

Various excursions were made by the members to points of interest in the vicinity of St. Louis: including one to open the Cahokia mound across the river in Illinois; another occupying Saturday, the 24th of August, to Iron Mountain and Pilot Knob; and, at the close of the meeting, there was an excursion to Colorado, to occupy a week or more.

Addresses were delivered Wednesday evening by Professor R. H. Thurston, Vice-President of Section A, on the "Science of the Advancement of Science;" and by A. R. Grote, Vice-President of Section B, on "Education a Succession of Experiences;" and on Thursday by Professor F. W. Clarke, Chairman of sub-Section C, on "The Cultivation of Chemistry." The address of the retiring President, Professor Simon Newcomb, delivered Thursday evening, on "The Course of Nature," was a philosophical discourse of more than ordinary interest.

The next meeting is to be held in Saratoga on the last Wednesday in August. The officers appointed for the meeting are Professor G. F. Barker, of Philadelphia, President; Professor S. P. Langley, of Alleghany, Pa., Vice-President of Section A; Major J. W. Powell, Vice-President of Section B; Professor Ira Remsen, Chairman of sub-Section of Chemistry; and Professor E. W. Morley, of Hudson, Ohio, Chairman of sub-Section of Microscopy.

The following is a list of the papers which were read, or accepted for reading, in the several sections.

I. *Mathematics, Astronomy and Physics.*

Experimental Determination of the Velocity of Light, A. A. MICHELSON.

An improved Method of Ringing a Bell in an Exhausted Receiver, T. R. BAKER.

On the Economic Use of Steam, C. A. SMITH.

On the Construction of a Sensitive Wind-vane, J. W. OSBORNE.—On Wind-vane Rotations, id.—The importance of Meteorological Observations in Vertical Section of the Atmosphere with the suggestion of means for their systematic accomplishment, id.

On Friction Measurement and its Laws, as determined by Recent Experiments for a wider range of Conditions than have been previously obtained, R. H. THURSTON.

Magnetic Determinations in Missouri, F. E. NIPHER.—Rain determinations on Roofs, id.

Tornadoes, Waterspouts and Hailstorms, W. FERREL.

On Finding the Differential of a Variable Quantity without the use of Infinitesimals or "Limits," J. FICKLIN.

Outline of Work done by the Fort Worth Solar Eclipse Party, J. K. REES.

A Peculiar Case of Fracture of Tool Steel, W. KENT.

On the use of the Tasimeter for measuring the Heat of Stars and of the Sun's Corona, T. A. EDISON.—On the application of the Carbon Button, id.—On the Principle involved in the Microphone and the Carbon Telephone, id.—A new Voltameter, id.

On the results of the Spectroscopic Observation of the Solar Eclipse of July 29, 1878, G. F. BARKER.—A new method of determining the Pitch of a Tuning Fork, id.

A Wind-wave thoroughly Sensitive and thoroughly Steady, W. C. TAYLOR.

On a Standard Inch and a Standard Centimeter, W. A. ROGERS.

On the Possibility of observing the Solar Corona without the aid of an Eclipse, O. STONE.

On a modified form of Telephone intended for a Sensitive Electroscope for the Detection of Feeble Currents, P. H. VAN DER WEYDE.

On the Development of Ozone in the Air, by means of Sudden Changes of Temperature, B. S. HEDRICK.

Internal Revenue Adjustment of the Carlisle Tables, E. B. ELLIOTT.—International Coinage, its progress, id.

On Recent Progress in Micrometry, R. H. WARD.

II. *Chemistry.*

A short account of the Nature of the Oxide of the New Element Mosandrum, J. L. SMITH.—The new Meteoric Mineral Daubréelite and its frequent occurrence in Nature in Meteoric Iron, id.

Electricity an Agent in Vegetable Growth, A. P. S. STUART.

The Electrolytic Estimation of Mercury, F. W. CLARKE.—Some new Selenocyanates, id.—Some Specific Gravity determinations and conclusions from them, id.

III. *Geology, Zoology and Botany.*

Ancient Glacial Action, Kelley's Island, Lake Erie, C. WHITTLESEY.

On Hybrids in Nature, T. MEEHAN.

Notes on the Life-history of the Blister-beetles, and on the structure and development of the genus *Hornia* Riley, C. V. RILEY.—On the larval growth of *Corydalus* and *Chauliodes*, id.—The Philosophy of the Movements of the Rocky Mountain Locust (*Caloptenus spretus*), id.—On the means by which Silkworm moths issue from their cocoons, id.—A New Source of Wealth to the United States, id.—Biological Notes on the Gall-making Pemphigini, id.

Dinosaurian Reptiles from the Jurassic of the Rocky Mountains, O. C. MARSH.

On the Complete Series of Superficial Formations in North Eastern Iowa, with Sections, W. J. MCGEE.

A new Fossil impression in a Glacial Bowlder, A. R. GROTE.

The Iron Ores of Alabama, with Special Reference to their Geological Relation, E. A. SMITH.

Embryology of Clepsine, (1) Stages preliminary to Cleavage, (2) Cleavage, Germ-lamellæ, Gastrula, etc., C. O. WHITMAN.

Extracts from Modern Science bearing on the Law of Repetition, Miss V. K. BOWERS.

Richthofen's Theory of the Loess in the light of the Deposits of the Missouri, J. E. TODD.

Are the so-called Chætetes of the Cincinnati Group Bryozoans? A. G. WETHERBY.—Remarks on the Geographical Distribution of the Land and Fresh-water Mollusks of the United States and their local varieties, id.

Notice of a recent discovery of Gold in the Unaka Mountains of Tennessee, J. M. SAFFORD.—Notice of Certain Sulphide Springs in Tennessee, id.

The Lands of Utah, J. W. POWELL.—The Rainfall of the Arid Region of the United States, id.

On a remnant of the Spiracles in *Amia* and *Lepidosteus*, B. G. WILDER.

On *Ægeria tipuliformis* Lin., G. H. PERKINS.—Osteology of *Sciuropterus volucella*, id.

On the Development of *Amia*, S. A. FORBES.

Remarks on the Early Decay of the male plant in *Cannabis sativa:* A Parallel and a Contrast, C. S. PERCIVAL.

The Relation of Adhesion to Horizontal Pressure in Mountain Dynamics, H. F. WALLING.—Some indications of Recent Sensitiveness to Pressure in the Earth's Crust, id.

Geological History of the Colorado River and Plateaus, C. E. DUTTON.

On the Consensus in Animal and Vegetal Life, L. F. WARD.

On some characteristics of the Vegetation of Iowa, J. C. ARTHUR.

On certain difficulties met with in using the Cat's Brain as a type of the brains of Mammals, B. G. WILDER.

The Alleged Volcano at Bald Mt., North Carolina, F. W. CLARKE.

The Gold Region of Georgia, G. LITTLE.

On the Compass Plants, G. ENGELMANN.

Discovery of Atlantosaurus and other Dinosaurs in the Rocky Mountains of Colorado, A. LAKES.

Exhibition of Fossils showing the effects of the Geodizing process, A. H. WORTHEN.

IV. *Anthropology.*

Ancient Mounds in the vicinity of Naples, Scott County, Illinois, J. G. HENDERSON.—Ancient Names, Geographical, Tribal and Personal, in the Mississippi Valley, id.

Description of two Stone Cists discovered near Highland, Illinois, A. OEHLER.

Description of a Cliff House in the Cañon of Mancos River, Colorado, with a Ground Plan of the structure, W. F. MORGAN.

Remarks on the Ruins of a Stone Pueblo on the Animas River, New Mexico, with a Ground Plan, L. H. MORGAN.—Observations on the San Juan River District, as an important ancient seat of Village Indian Life, id.

On the Sources for Aboriginal History of Spanish America, A. F. BANDELIER.

Remarkable Burial Custom from a Mound in Florida: The Cranium utilized as a Cinerary Urn, H. GILLMAN.—Description of a Glazed Earthen Vessel, taken from a Tumulus in Florida, id.

Evidences of Cannibalism in a Nation before the Ainos in Japan, E. S. MORSE.

Remarks upon the Archæology of Vermont, G. H. PERKINS.

An Atlas of North American Antiquities, O. T. MASON.—North American Indian Synonymy, id.

Ancient Pottery from Chiriqui, Central America, O. C. MARSH.

On the anatomical peculiarities by which Moundbuilders' Crania may be distinguished from those of the Modern Indian, W. J. MCGEE.

Exhibition of Prehistoric relics from Missouri, A. J. CONANT.

An account of an exploration of a Walled Town of the Moundbuilders of the Cumberland Valley, F. W. PUTNAM.

On the Discovery of a Human Skull in the Drift near Denver, Colorado, T. BELT.

2. *Pennsylvania Geological Survey.*—Two new volumes of Reports of this Survey have appeared: on the Fayette and Westmoreland District of the Bituminous Coal Field, by J. J. STEVENSON. Part ii, Ligonier Valley. 330 pp. 8vo, with maps and woodcuts; and Two Hundred Tables of Elevation above Tide Level of the Railroad Stations, Summits and Tunnels, Canal Locks and Dams, etc., in and around Pennsylvania, by CHARLES ALLEN. 280 pp. 8vo.

Professor Stevenson, in his volume, besides describing with detail the stratification and coal beds of the region, gives in chapter 18, a partial statement of the facts on which were based the conclusions offered in the May number of this Journal, observing that the full discussion will be given elsewhere in the fall; in chapter 19, he discusses the relations of the axes west from and including the Alleghenies of Pennsylvania; traces the axes to their final disappearance in West Virginia; shows that they are suc-

cessively shifted eastward, and that each axis is practically overridden by its eastern neighbor, until the whole system is swallowed up by the great Tygarts Valley anticlinal of West Virginia; in chapter 20 he discusses the age of the axes and shows that the more important ones existed early during Coal-Measure times. On page 282 are some conclusions respecting four of the coal-troughs; chapter 21 treats of the structure of coal-beds and intervals between coal-beds; shows that coal-beds divide; that in the great trough, the groups thin out east, north and west; also contains a brief discussion of the nature of clay veins, besides giving a few notes on the Paleontology of Southwest Pennsylvania and imperfect lists of fossils observed.

3. *Meeting of the British Association.*—The meeting of the British Association for 1878 was held at Dublin during the week from August 14 to August 21. The opening exercise upon Wednesday evening, the 14th, was the Inaugural Address by the President-elect, Mr. William Spottiswode; it was devoted to a discussion of the "External aspects and tendencies of Mathematical Science." Opening addresses were also made in the several sections by their respective presidents, as follows: in Chemistry, by Professor Maxwell Simpson; in Geology, by Mr. John Evans; in Biology, department of Botany and Zoology, by Professor W. H. Flower, and by the vice president, Mr. R. McDonnell, in the department of Anatomy and Physiology; in Geography, by Professor C. Wyville Thomson; in Mechanical Science, by Mr. Edward Easton. Lectures were delivered by Mr. Romano upon Animal Intelligence, and by Professor Dewar on Dissociation, or Modern Ideas of Chemical Action. A considerable number of papers were presented for reading. The attendance was much larger than at the last general meeting, the number of persons present amounting to 2,577. Among the various reports presented, was one by the committee appointed to "consider the advisability and to estimate the expense of constructing Babbage's analytical engine and the printing of tables by this means. The committee while praising the work of Mr. Babbage as a marvel of mechanical ingenuity and resource, and though admitting the utility of such an engine as he had planned, decided that they could not advise the British Association to take any steps toward having it constructed. Dr. Allman was elected president of the meeting to be held in 1880 at Swansea.

4. *A new form of Telephone;* by A. Floyd Delafield, A.B., Noroton, Conn.—In the ordinary forms of telephone a piece of iron moves near a magnet surrounded by a coil of wire. Movements of the iron produce changes in the strength of the magnet and thus currents are induced. Generally the iron is used in the shape of a thin plate. The size of the plate being determined within pretty narrow limits by acoustic requirements, the strength of the magnet which can be used is also limited.

The magnets which I use in the new form of telephone are shaped like a W; two U magnets with, say, their N. poles bolted

together, while their S. poles form the two outer branches of the W. The middle bar fits the center of the coil, while the outer ends nearly touch it on the outside. The number of lines of force perpendicular to the direction of its motion which are cut by the coil is much increased by this disposition of the poles of the magnet.

Bibliography of North American Invertebrate Palæontology, by C. A. White, M.D., and H. Alleyne Nicholson, M.D., etc. 132 pp. 8vo. Washington, 1878. Department of the Interior U. S. Geol. Survey of the Territories; Miscellaneous Publications, No. 10.

Annual Report of the Chief Signal Officer to the Secretary of War, for the year 1877. 570 pp. 8vo, with twenty charts. Washington, 1877.

Annual Report upon the Survey of the Northern and Northwestern Lakes and the Mississippi River in charge of Gen. C. B. Comstock and Capt. H. M. Adams. Appendix LL of the Annual Report of the Chief of Engineers for 1877. Washington, 1877.

Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. Vol. iv. The terrestrial air-breathing Mollusks of the United States and the adjacent Territories of North America, described and illustrated, by W. G. Binney. Vol. v. Text, 439 pp. 8vo; vol. v. with 74 plates for vol. iii, and 16 plates of vol. v.

Observations and orbits of the Satellites of Mars, with data for Ephemerides in 1879, by Asaph Hall, Prof. Math. U. S. Navy. Rear-Admiral John Rodgers, U. S. Navy, Superintendent of the Naval Observatory. 46 pp. 4to. Washington, 1878.

Anales de la Oficina Meteorologica Argentina, por su Director Benjamin A. Gould; Tomo I, Clima de Buenos Aires. 522 pp. 4to, with 17 plates. Buenos Aires, 1878.

Metals and their chief industrial applications; being with some considerable additions the substance of a course of lectures delivered at the Royal Institution of Great Britain in 1877, by Charles R. Alder Wright, D. Sc., etc. 191 pp. 12mo. London, 1878. (Macmillan & Co.)

The Ancient Life-history of the Earth; a comprehensive outline of the principles and leading facts of palæontological science, by H. Alleyne Nicholson, M.D., Ph.D., etc. 407 pp. 8vo. New York, 1878. (D. Appleton & Co.)

OBITUARY.

Rev. W. B. Clarke, a geologist of eminence in Australia, as well as a clergyman of the Church of England, died on the 16th of June last at St. Leonards (near Sydney), New South Wales, at the age of eighty-five. Mr. Clarke was an enthusiastic worker in geology. His labors in Australia were continued for more than forty years, and resulted in many important discoveries and great progress to Australian geology. The first announcement of gold in Australia was claimed by Mr. Clarke; and from that time, in 1851, Australia began its career as a gold-producing continent. Mr. Clarke was an active member of the Royal Academy of New South Wales, and for several years its Vice-President. His scientific publications are papers read before the Geological Society of London; anniversary addresses as Vice-President of the Royal Society; and various pamphlets on geological discoveries in Australia and Australasia, with one on the Causes and Phenomena of Earthquakes especially in relation to shocks felt in New South Wales and in other Australasian Provinces. He was a man of great excellence and of earnestness in his parish work as well as in his field explorations.

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ART. XXXVIII.—*On some points in Lithology*; by JAMES D. DANA.

I. ON SOME OF THE CHARACTERS EMPLOYED IN DISTINGUISHING DIFFERENT KINDS OF ROCKS.

LITHOLOGY is a department of Geology, rocks being the material in and through which geological problems are presented for study. The true aim of the science of lithology is to describe the kinds of rocks mineralogically and chemically, and to note down their distinctions, in such a manner as shall best contribute to the objects of geology; and these latter objects include, as regards rocks, the origin of the minerals, and mineral associations, constituting or occurring in rocks: the origin of the rock masses and their relations to other geological phenomena; and the origin of all changes or transformations that have taken place in rocks in the course of the earth's physical development. Geology, chemistry and mineralogy have each to be considered in determining the proper distinctions between the kinds of rocks. Should lithology make much of mere difference in texture, or in ingredients that are present only in minute proportion, geology might rightly say that, for such a purpose, these points are of small importance compared with the nature or composition of the mass.

The defining of rocks is attended with special difficulties on account of their mutual transitions. From granite down they are, with very few exceptions, mixtures of minerals, as much so as the mud of a mud bank. They graduate into one another by indefinite blendings, as the mud of one mud bank graduates into the mud of others around it. In fact a large part of the

crystalline rocks were once actual mud beds or sand beds; and even part of the eruptive rocks may have been so in their earlier history. Strongly drawn limits no where exist. Rocks are hence of different *kinds*, not of different *species;* and only those mixtures are to be regarded as *distinct kinds* of rocks which have a sufficiently wide distribution to make a distinct name important to the geologist. Other kinds have to be classed as *varieties*, if worthy of that degree of recognition.

In the following pages I propose to consider the value of some of the distinctive characters which are generally accepted at the present time in defining certain kinds of rocks.

1. "*Older*" *and* "*Younger*."—The distinctions "older" and "younger," often applied to a number of kinds of eruptive rocks, seem to imply that the earth has generated different *kinds* of rocks as it has grown old. The terms have reference, however, to only one epoch of abrupt change—that between the Cretaceous and Tertiary, "older" signifying pre-Tertiary and "younger," Tertiary or later in date. It is of eminent importance to geology to know definitely whether this epoch was one of great change in the earth's ejections, and an epoch so marked that the rocks on one side of the time-boundary are deserving generally of different names from those of the other; for thus lithology, judging from some recent works, as well as older, has seemingly decided.

Some examples of the "older" kinds are *dioryte*, *diabase*, and a large part of *felsyte;* and some of the "younger" are *propylyte*, *doleryte* or *basalt*, and *trachyte*. The value of the distinction may be learned from a comparison of the rocks of one of these series with the rocks of the other.

First as to *diabase* and *doleryte*. Typical diabase consists, according to the descriptions, of labradorite and augite, with some magnetite or titanic iron: and so does doleryte. Diabase, to a large extent, is a crystalline-granular rock; so is doleryte. Diabase was formerly supposed to be peculiar in containing chlorite, but it is now proved, as asserted by Rosenbusch, that chlorite is not an essential characteristic, so that diabase may be chloritic or not; and the same is true of doleryte. Old diabase was described as differing from the younger rock doleryte in containing no glassy portions or grains among the crystalline grains; but this also is set aside by later observations, and Rosenbusch accordingly divides diabase into (1) massive granular diabase, (2) diabase-prophyrite, and (3) glass-bearing diabase; and corresponding subdivisions are as good for doleryte. Thus in chemical composition, in mineral composition, in texture, in the presence or absence of chlorite, in the presence or absence of glassy portions, the two rocks are identical. Analyses of "diabases" from the Archæan to the Tertiary, and of

"dolerytes" of subsequent time, have shown that material of essentially the same chemical composition, has been ejected in all geological ages, as has been well urged by Allport and others. The analyses might be cited; but this is not necessary, since in mineral composition typical diabase and doleryte are admitted to be identical.

The fact as regards these two rocks, then, give no foundation for the idea of such a transition epoch in rock-making at the close of the Cretaceous period. And if not, it is bad for geology to have such epithets as "younger" and "older" treated with so great distinction.

Again: the difference between *dioryte* ("older") and *propylyte* ("younger") is not in the chemical or mineral composition of the rocks; and hence, whatever difference there be is only in texture and is, therefore, of little geological value.

Again, *felsyte* and *trachyte* are rocks of one and the same chemical and mineral constitution. Ordinary felsyte consists of orthoclase, or orthoclase and oligoclase, with sometimes disseminated hornblende or quartz; and the same is precisely the constitution of kinds of trachyte. They differ in aspect, and feel differently under the fingers; and still some varieties of felsyte differ from ordinary trachyte only in having the disseminated orthoclase crystals not translucent, a difference of very small value mineralogically and not less so geologically. The rock of certain felsitic dikes in Canada and Vermont, Paleozoic in age, is called trachyte by T. Sterry Hunt, in the Canada Geological Report, because of the essential identity with that rock; and Mr. G. W. Hawes, in his New Hampshire Report says (p. 187), of New Hampshire's "orthoclase-porphyry," "were it not that the feldspar is opaque orthoclase instead of clear sanidin [that is, glassy orthoclase] one would immediately think of trachyte on examining these rocks." Moreover, Messrs. E. Reyer and Suess, eminent geologists of Vienna, have shown that trachyte occurs in the Euganean Hills of Cretaceous and Jurassic age, as well as of Tertiary. Further, there are felsytes among the "younger" rocks of the globe, that is, among the products of volcanoes, where there is no trachyte: and on the other hand, trachyte sometimes graduates indefinitely into felsyte.

The facts show, consequently, that orthoclase rocks, or orthoclase and oligoclase, have been erupted from Paleozoic time onward, and that the distinctions found in some of the latest kinds are superficial: a little rougher surface, more translucency in the feldspar, and some glass at times among the crystalline grains; but nothing that has any geological weight. While then it may be well to retain the names of trachyte and felsyte, on account of the obvious external differences and the

wide extent to which the two varieties of rock are distributed over the earth's surface, the epithet "younger" as applied to trachyte and some felsyte can subserve plainly no good use.

The essential chemical identity of the "older" and "younger" rocks is further exhibited in the fact that the hornblende-bearing rock *labradorite-dioryte*, called one of the "older," has the same ultimate constitution as the augite-bearing rocks "older" and "younger," called diabase, doleryte and basalt. This fact emphasizes the great truth, that the rock-making materials of former time are the same as those of recent.

During and since the Tertiary era more true subaerial volcanic eruptions have taken place than in any one ancient period; but there were also many then. As to fundamental differences between the materials ejected by the "older" and "younger" world there appear to be none which are of essential importance. *Glass or no glass* is made an important criterion; but glass is simply a result of comparatively rapid cooling and alone indicates no essential differences in the melted mass.

Dropping the adjectives "younger" and "older" would require the dropping of the distinctive names based on them, unless some better reason exists for retaining them.

If diabase is not distinct from doleryte in some important way besides that of time of eruption, the name *diabase* (the newer of the two) is unnecessary. In fact, the rocks are not distinct in external characters any more than in chemical or mineralogical. The rock of the Giant's Causeway was pronounced diabase on microscopic grounds when its geological age was unknown; but it has since been proved to be Miocene Tertiary; and now although just as much diabase in constitution as before, it becomes, on the "younger" and "older" scale, doleryte or basalt.

Some of the differences attributed to difference in age may be due to differences in origin—that is, to the rock's being metamorphic in one case, and eruptive in another. There are distinctions of this kind of great interest yet to be followed out; and they may sometimes have a sufficient geological value for recognition in distinct names, although this may not be generally the case.

2. *Foliated or not.*—Some rocks are described as having foliated pyroxene or foliated hornblende, that is, diallage, pseudo-hypersthene or smaragdite, as the characterizing ingredient. The question here is whether the distinction of *foliated* or *not foliated* is of sufficient importance to be used as a distinction among kinds of rocks.

In the *first* place it is trivial as a crystallographic distinction. *Secondly*, although mineralogy once made much of the distinc-

tion, it now makes little of it. *Thirdly*, it is not sustained by the analyses of the varieties of foliated pyroxene—diallage, and the wrongly called hypersthene being essentially identical in composition with common augite of eruptive rocks, and the smaragdite with other crystallized hornblende. This is shown in any work giving full lists of analyses of minerals, and is well understood; yet the introduction here of a few of the analyses may not be superfluous. Nos. 1 to 5, are of diallage and pseudo-hypersthene, and 6 to 8 of augite crystals from Etna and Vesuvius.

	SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	H_2O		
1. Florence, *Diall.*	53·20	2·47	8·67	0·38	14·91	19·09	1·77	=100·49,	Köhler.
2. Piedmont, *Diall.*	50·05	2·58	11·98	—	17·24	15·63	2·13	= 99·61,	Regnault.
3. Graubündten, *Diall.*	49·12	3·04	11·45	—	15·33	18·54	1·46	= 99·94,	v. Rath.
4. Harzburg, *Hyp.*	52·34	3·05	8·84	—	15·58	19·18	0·66	= 99·65,	Streng.
5. Neurode, *Hyp.*	53·60	1·99	8·95	0·28	13·08	21·06	0·86	= 99·82,	v. Rath.
6. Etna, *Augite Cryst.*	50·55	4·85	7·96	—	13·01	22·29	—	= 98·66,	Kudernatsch.
7. Vesuvius, "	50·90	5·37	6·25	—	14·43	22·96	—	= 99·91,	Kudernatsch.
8. Vesuvius, "	49·61	4·42	9·08	—	14·22	22·83	—	=100·16,	Rammelsberg.

The mineralogical and chemical differences are thus too slight to make the distinction of any lithological importance, and this importance can be sustained, if at all, only on geological considerations.

The particular rock, in the description of which the character stands prominent, is that called *Gabbro* in Germany. It is well known that this Italian word was the provincial name originally of common serpentine. Ferber in his "Briefe aus dem Wälschland" (Letters from Italy), written in the years 1771, 1772, and published in 1773, describes so well the rock near Florence, that we cite briefly from him. He first says, in a letter from Florence of Dec. 11, 1771, (in which he gives scientific notes on the minerals and rocks of the region) that the Gabbro of the Italians, occurring in Italy, Tuscany and Genoa, is identical with the serpentine of Saxony. Then, in another, of May 23, 1772, he repeats the statement and describes particularly, and with scientific precision, the gabbro of Mt. Impruneta, near Florence, and mentions the occurrence in it of a talky micaceous mineral which affords, he says, a powder greasy to the touch (the diallage) and also amianthus. He then adds that "in *horizontélen* Schichten in den Gabbro-Bergen um Impruneta findet sich der sogenannte *Granitone*, welcher aus weissen Feldspat, der an einigen Stellen Kalchspatartig ist und mit Säuren brauset, etwas grünlichtem silberfarbigen würflichten Glimmer, und grünlicher Serpentin-Erde, besteht:" a description that distinguishes the gabbro from the granitone. Further, he says, that some of the granitone consists of the "white feldspar in large parallelopipeds and green gabbro-earth, without the micaceous mineral."

The word *Gabbro*, as it is now used (and was so first by von Buch in 1810) is applied to the *granitone*, the associate of the Italian gabbro; but, besides this, to rocks consisting of foliated pyroxene (sometimes called hypersthenite), and cleavable labradorite the idea of *foliated* standing out prominently; and also to an eruptive diabase-like or doleryte-like rock, in which the augite happens to be *foliated*.

In this last variety, as the analyses show, there is evidently no foundation whatever for separating the rock from other labradorite-augite eruptive rocks.

Granitone is the same as *euphotide*, a rock distributed at intervals along the Alps from Savoy and Isère in France through Piedmont, to the valley of the Saas, north of east of Monte Rosa, and the Graubündten, occurring also in Silesia and on the island of Corsica, and found commonly associated with serpentine. Its chief characteristic is—not its *foliated* diallage or smaragdite (either of which is usually a mixture of hornblende and pyroxene), but its consisting largely of the compact jade-like material called *saussurite;* for it would be the same rock, essentially, whether the hornblende and pyroxene were distinctly foliated or not; and, in fact, in part of it the texture is aphanitic, and nothing foliated is distinguishable.

Saussurite has a close relation to some of the feldspars in its constituents, it being essentially a soda-lime-alumina silicate; and still, as has long been recognized, it is not a feldspar. This has been rightly sustained by the fact of the high density, which is over 2·9 (2·9 to 3·4), in saussurite, and less than 2·765 in the feldspar group. It is further proved by its occurrence occasionally under the crystalline forms of a triclinic feldspar, but with a fine granular or aphanitic structure; thus having, instead of the cleavage structure belonging to the feldspar, a feature belonging to a pseudomorph. In such cases it was once feldspar; but some change has come over it that has resulted in a molecular transformation, affecting both the crystalline character and the density. Saussurite appears to cover a group of minerals, like feldspar. *One* kind is between anorthite and zoisite in composition, though differing from both in the soda and magnesia, and from all feldspars in its not having the feldspar-ratio between the silica and soda. A *second* has the composition of labradorite; and a *third* the composition nearly of oligoclase. A *fourth*, from Corsica, analyzed by Boulanger, is a lime-alumina silicate, like anorthite and zoisite. The saussurite group, with density between 2·9 and 3·4, runs nearly parallel with the feldspar group. The first is *Saussurite*, Th. de Saussure having named thus the Lake Geneva variety, after his father, in 1806; the third is *Jadeite;* and the second may be called, from one of its localities, *Genevrite*.

The following are analyses of the three prominent kinds, and of normal anorthite, labradorite and oligoclase.

	SiO_2	AlO_3	FeO_3	FeO	MgO	CaO	Na_2O	K_2O	ign.		
I.											
L. Geneva	43·59	27·72	2·61	—	2·98	19·71	3·08	—	0·35	=100·04,	Hunt.
L. Geneva	45·34	30·28	—	1·37	3·88	13·87	4·23	—	0·71	= 99·68,	Fikenscher.
Schwartzwald	42·64	31·00	—	2·40	5·73	8·21	3·83		3·83	= 97·64,	Hütlin.
II.											
Mt. Genèvre	49·73	29·65	—	0·85	0·56	11·18	4·04	0·24	3·75	=100·00,	Delesse.
Silesia	50·84	26·00	2·73	—	0·22	14·95	4·68	0·61	1·21	=101·24,	v. Rath.
Silesia	51·76	26·82	1·77	—	0·35	12·96	4·61	0·62	0·68	= 99·57,	Chandler.
Unst	52·21	29·64	0·48	—	0·26	12·43	4·00	0·44	0·11	= 99·56,	Heddle.
Unst	53·14	29·99	0·25	—	0·21	12·29	3·86	0·47	0·21	=100·42,	Heddle.
Durance	56·12	17·40	7·79	—	3·41	8·74	3·72	0·24	1·93	= 99·35,	Delesse.
III.											
Jadeite, China	59·17	22·58	—	1·15	1·15	2·68	12·93	*tr.*	—	=100·07,	Damour.
" Switz. ...	58·89	22·40	—	1·28	1·28	3·12	12·86	0·49	0·20	=100·63,	Fellenberg.
" " ...	58·28	21·86	—	2·41	1·99	2·53	13·97	—	—	MnO 0·22,	Fellenb.
Normal anorthite .	43·1	36·9	—	—	—	20·0	—	—	—	=100	
Normal labradorite	52·9	30·3	—	—	—	12·3	4·5	—	—	=100	
Normal oligoclase .	61·9	24·1	—	—	—	5·2	8·8	—	—	=100	

Specific gravity of 1, 3·227; of 2, 3·3–3·4; of 3, 3·16; of 4, 3·10; of 5, 2·998; of 6, 2·74; of 7, 2·95; of 8, 2·954; of 9, 2·923; of 10, 3·33–3·35; of 11, 3·32; of anorthite, 2·66–2·763; of labradorite, 2·67–2·76; of oligoclase 2·56–2·72.

To No. 9, add CrO_3 0·51, and to 11, ZnO 0·73. Nos. 10 to 12 are only known worked into ornaments, but the kind may yet be found in the Alps. No. 6 has the specific gravity of labradorite and was therefore that species, a mineral that would be present where the crystallization took place without, or with only partially, the conditions needed to produce saussurite. No. 9 is of the globules of the "Variolite of Durance," a rock associated with euphotide.

Boulanger's saussurite, from Corsica, is near *zoisite* in composition and density (G.=3·18), as stated by T. S. Hunt, who referred all true saussurite to zoisite (confirming his view by his analysis above), and the part near labradorite to that of feldspar. Damour obtained for *jadeite* the ratio 1 : 2 : 6.

The relation to the feldspar group indicates the occurrence of special geological circumstances, which turned feldspathic material into saussurite. The circumstances that determined the crystallization or metamorphism may have produced, in its incipient stage, soda-lime feldspar; but it ended in making a large *part*, or the *whole*, saussurite. Moreover the hornblende has been shown to be in part, at least, pseudomorphous after pyroxene; so that the foliated ingredient bears like evidence in favor of this mode of origin. Consequently saussurite rocks not only differ molecularly from any labradorite or feldspar rock, but are indications of peculiar geological operations on a large scale; and this, connected with other differences, makes it desirable to distinguish such rocks by a special name. The saussurite, and not the *foliated* mineral, is the chief ingredient on which the distinction rests.

Euphotide is therefore a different rock from any consisting of *cleavable* labradorite and pyroxene or hornblende, both on mineralogical and geological grounds. The *foliated* condition of the latter constituent is not reason enough for overlooking

the more fundamental differences. As the name *gabbro* has covered rocks of so different kinds, lithology would be freer of ambiguities without it.

The true labradorite-and-pyroxene rock of Scandinavia, the Adirondacks, British America and other regions, sometimes called *Noryte*—the third kind of gabbro—has the chemical and mineralogical constitution of diabase or doleryte. But it differs from these in its granitoid aspect and geological relations, and is of metamorphic origin; and as it is of wide geographical distribution, geology seems to require for it a distinct name, and *noryte* is an appropriate one. The pyroxene, though generally foliated, is not always so. When, in place of pyroxene, there is *true* hypersthene, a mineral of different composition and character, as at St. Paul's, Labrador, the rock is then rightly called *Hypersthenyte*, and this name is so used by Zirkel.

3. *Porphyritic Structure.*—Porphyry naturally took the position of a species in the mineralogy of the ancients. But it is now well known, and generally admitted, that the porphyritic structure is largly due to conditions attending the former temperature and cooling of the rock-mass, and distinguishes only varieties. But still it is usual to find dioryte divided, for its primary subdivisions, into ordinary dioryte and dioryte-porphyry; diabase into granular diabase and diabase-porphyry or diabase-porphyrite; felsyte into felsyte and felsyte-porphyry; and so on, as if the porphyritic structure were deserving of first prominence in the question of division into varieties, even greater than mineral constitution; and sometimes it is even made the basis of a distinct kind of rock.

But, *first*, this porphyritic feature is only one grade in the crystalline condition, and is of no more value as regards rock-distinctions than other grades.

Secondly, it is of far less importance in this respect than any variations in chemical or mineral compositions, such as are made the basis of other varieties.

Thirdly, it has often little stability in a rock-formation: for transitions in a dioryte from porphyritic dioryte to non-porphyritic are often found to take place at short intervals, laterally as well as vertically; and so it is with other porphyritic rocks. Within three miles west of New Haven, Connecticut, a labradorite-dioryte undergoes many such transitions in intervals of a few rods, illustrating the little value of the distinction based merely on this condition in the feldspar. Half a dozen miles farther west there is porphyritic granite which graduates *in a few yards* at some points into porphyritic gneiss (the crystals of orthoclase, two inches long and three-fourths of an inch broad) and this last graduates near by into ordinary gneiss; and gradations from porphyrytic to ordinary

gneiss are very common in the region. Such facts make it evident that the porphyritic structure is a characteristic of little relative importance; that a porphyritic variety may have rightly a place on a level with other ordinary varieties, but never above one based on variations in composition.

The porphyritic structure is an easy character to observe, but this is not an argument in its favor that science can entertain. Such names as *felsite-porphyre*, *amygdaloporphyre*, *granito-porphyre*, *melaphyre* (this last signifying "black porphyry") and others (abbreviated sometimes to felsophyre, amygdalophyre, granophyre, etc.) have high authority. But they seem to belong rather to books on polished stones than to scientific works on lithology.

The occurrence also of the augite of an eruptive rock in distinct crystals, or of quartz in double pyramids, and other similar cases, can have nothing more than a small *varietal* value. The criterion—crystals or not—is sufficient to distinguish only varieties in mineralogy; and lithology can rightly make no more of it.

[To be continued.]

ART. XXXIX.—*On the Spectrum of the Corona*; by W. T. SAMPSON, U. S. N.

SO FAR as I can learn from the daily papers, there seems to be a considerable unanimity of opinion as to the nature of the light of the corona. My observations, made at Separation, with Prof. Newcomb, lead me to a somewhat different conclusion from those above referred to; I therefore ask leave to describe my work.

Like many other observers of the eclipse I had set myself the task of determining the source of the light of the corona; and this I *attempted only* so far as to decide by the presence or absence of dark lines in the spectrum of the corona, whether the light was the reflected light of the sun or due to the self-luminous material, or whether it was due to both these combined. For this work I used a direct vision five-prism spectroscope, made by Browning, attached to an equatorially mounted telescope of 3½ inch aperture and about five feet focal length. In addition I had prepared to use a hand polariscope consisting of a double-image prism and mica plate. These were the best tools for the work at my command. A few days before the eclipse Mr. Lockyer asked me, if time permitted, to examine with a radial slit whether the 1474 line came close down to the sun's surface or broke off some distance above it. Previous observers were somewhat at variance as to the fact

and upon it seemed to depend the simple or compound nature of the gas emitting the green light. I therefore determined to commence my work by adjusting the slit tangent to the disappearing limb of the sun at the beginning of totality in order to witness the reversal of the Fraunhofer lines, so admirably seen by Prof. Young in 1870, but not visible to some observers who looked for them in 1871. I proposed to look particularly for the 1474 line with the slit in this position and then to place it radially to see if the line thickened as it approached the sun's surface. The remainder of the time was to be devoted to the dark lines of the coronal spectrum and to the polariscope. I was fortunate in securing the services of Dr. Dewitt, M.D., U.S.A., to direct my telescope. During two days we practiced upon the changes and adjustments I had decided upon making during totality. By practice upon bright clouds, the sky and the moon, I decided that I could open the slit to ·1 mm. while searching for the dark lines. All previous observers had described the continuous spectrum as faint. It was therefore necessary to use a slit as wide as possible and at the same time be certain of seeing the lines. As totality approached we adjusted the slit carefully tangent to the narrow crescent of the sun. The slit plates had previously been covered with white paper to secure a distinct image of the corona at the focus of the objective. The telescope of the spectroscope was clamped so as to have the spectrum from about C to F in the field. Placing my eye at the telescope in time to get the last glimmer of the solar spectrum, I was greatly surprised an instant after at the brilliancy with which the bright lines appeared, flashing out at once to their maximum brightness. The time during which this beautiful sight lasted was not sufficient for me to positively identify the lines; yet their familiar grouping left no doubt in my mind that they occupied the places which a moment before had been occupied by the dark lines of the solar spectrum. The continuous spectrum of the sun entirely disappeared before the bright lines made their appearance. I could not estimate the number of bright lines that were in the field during the probable two seconds they were visible, but they were very numerous and the impression left upon my mind was that their brilliancy corresponded to the darkness of the same absorption bands in the solar spectrum. From its brightness and position I am confident I saw the 1474 line. When this brilliant line spectrum vanished, no lines either dark or bright were visible, but a continuous spectrum held its place. I did not notice any continuous spectrum while the lines were visible.

As previously arranged the slit was placed radially, still nothing was visible but a continuous spectrum, not bright.

'he slit was at this time open ·02 mm. to which it was set be-
ore the eclipse began. The spectroscope was now rotated 90°
nd the slit opened to the division of the screw-head previously
lecided upon. The spectrum was then much brighter than I
ad anticipated. I directed my assistant to move the slit grad-
ally away from the sun through the brightest part of the
orona. This was done until the spectrum disappeared, when
t was moved back again. The spectrum being so bright I
lirected the slit to be partly closed. I do not know how wide
t was during the latter part of my search and omitted to exam-
ne it after the eclipse, but I estimate that it was not more than
)5 mm. The image of the corona on both sides of the sun,
ast and west, was caused to slowly move over the slit, yet no
race of a break in the continuous spectrum was visible.
'hough the spectroscope was adjusted for sharp definition of
ines between C and F, I repeatedly swept over the whole length
f the spectrum. I am confident that if the dark lines had ap-
roached in distinctness those of the solar spectrum they could
ot have escaped my attention, which was continued to the end
f totality. Two minutes at least was devoted to this search.
'he conclusion therefore forces itself upon my mind that the
ght of the corona is not all reflected light. Several considera-
ions I think lead to this conclusion. Until this eclipse no
bserver has ever seen the dark lines in the spectrum of the
orona except M. Janssen, who reported dark lines, notably D
n 1871, but much more difficult to see than the bright lines.
everal observers during the recent eclipse failed to see the dark
ines, though they looked for them carefully. While I do not
uestion the results of observers who report the presence of
ark lines I think all the observations taken together show
hat the continuous spectrum of the corona is not the spectrum
f the sun. Aside from this, Prof. Arthur W. Wright made
neasurements of the polarization of the light of the corona,
he first time I think it has been attempted, and has found
he polarization to be but a small percentage of the whole light
mitted. Although all reflected light does not reach us as polar-
zed light, yet I think the small percentage of polarization
aken with the faintness of the dark lines indicates that the cor-
na is to a considerable extent self-luminous. The meteoric
ust not only reflects the sun's light but it is continually show-
ring upon the sun and in its passage through its atmosphere
rendered incandescent.

No photographs of the spectrum of the corona can probably
hrow any light upon the matter.

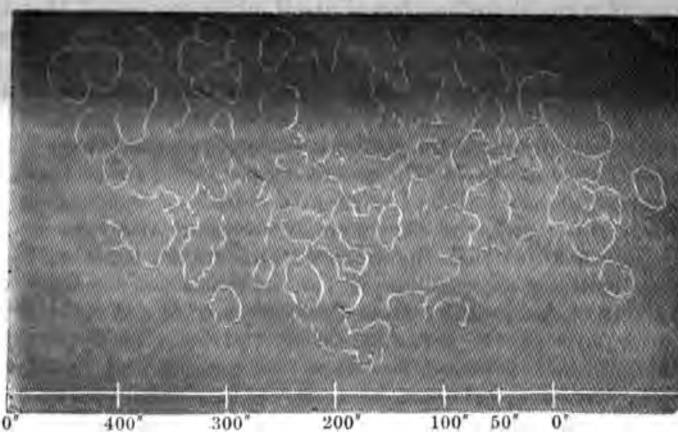
August 31, 1871.

ART. XL.—*Note on the Reticulated Forms of the Sun's Surface;* by EDWARD S. HOLDEN. Communicated by permission of Rear Admiral John Rodgers, Supt. U. S. Naval Observatory.

ON September 16 and succeeding days a watch was kept on the sun's disc, at the request of Professor Watson, for a possible transit of Vulcan.

Just before noon of September 16, Professor Eastman called my attention to certain cloud-shaped forms on the sun's disc which were visible when the sun's image, seen by projection, was allowed to move across a white screen. This was with the 9·6 inch Munich equatorial. I immediately turned the 26-inch equatorial (with aperture reduced to six inches and power 200) upon the sun and caused it to follow the sun by the driving clock. The image was thrown on a white screen about twelve inches from the focal plane and the shadows of the micrometer wires (which were placed 100″ apart) gave a scale of reference.

1.

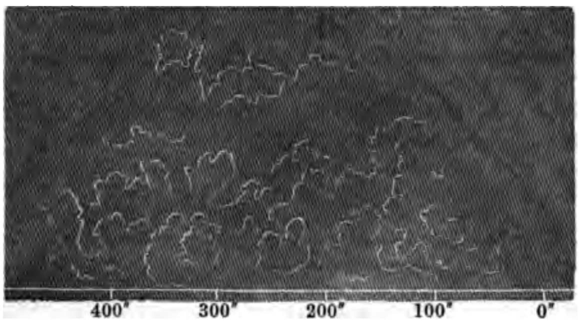


Reticulated Structure of Solar Surface.

The general mottling of the surface was not so well seen when the telescope was driven by the clock, as when the image was allowed to move across the screen. But close attention showed the whole surface to be covered by a network of dark lines 2″–3″? in thickness, each bounding an area which in general shape strongly suggested the polygonal forms photographed by Janssen and previously described and figured by Huggins and Langley. The area bounded by these lines was not seen filled by the smaller forms of Janssen. These dark lines when

seen were traced upon the screen by pencil lines and the result is shown in fig. 1. The representation is rough at best, but it has the merit of fidelity. As I was in doubt as to the meaning of my sketch and almost as to the real nature of the appearances, I enclosed it to Professor Langley and received from him the accompanying sketch, made July 25, 1873, at Allegheny, and a letter, a portion of which I quote with his kind permission.

2.



"ALLEGHENY OBSERVATORY, Allegheny, Pa., Sept. 23, 1878.

"The reticulated surface-forms, seen in good definition, occupied me at one time, and I enclose one of my early sketches reduced to the same scale as yours. In the very *best* definition I think you would find these less conspicuous—not that they are a product of poor seeing, but that an exquisite definition fills the field with details of which these seem but the aggregations. Yet it cannot be said to be absolutely sure that this obscuration of detail may not occur in the sun itself and present itself in the best seeing. I am disposed to admit the possibility of this, while holding that the change is *chiefly* from our own atmosphere. It is at any rate interesting to see how well our drawings agree in giving a certain uniformity of size to these clusters (clusters of smaller objects I take them for).

It is quite clear that there is an essential agreement here between our entirely independent sketches."

It should be mentioned that at Washington the definition was exceptionally good. The steadiness of the image I should call Wt. 4 on a scale of 5 = perfectly steady; 1 = extremely unsteady. The sky was quite clear.

It has seemed to me since receiving Professor Langley's letter that these observations should be recorded, in spite of their fragmentary character.

U. S. Naval Observatory, Oct. 1, 1878.

ART. XLI.—*Observations of Bright Meteors;* by EDWIN F. SAWYER.

THE following short list of meteors, equal to or exceeding first magnitude stars in brightness, have lately been recorded by me during some regular period of watching, at Cambridge, Mass. The times of apparition may be considered as accurate to within half a minute. The list is given for publication in hope that other observers may have recorded some of them, in which case interesting and valuable results can be deduced.

No. 14 was also seen and mapped by Mr. S. C. Chandler, Jr., at Marlboro, N. H., further particulars of which, together with the results deduced from others doubly observed by Mr. Chandler and the writer during the last of August, will be given in a future communication.

No.	Date. 1878.	Mean time.	Magnitude.	Observed path. From R. A.	From Dec.	to R. A.	to Dec.	Length of path.	Remarks.
		h. m.		°	°	°	°	°	
1	July 22	10 5	1	305	+58	313	+69	11+	Rapid; blue.
2	July 23	9 21	1	306	+45	312	+42	6	Quite slow; across α Cygni.
3	July 23	10 4	1	315	+ 9	318	− 1	10	Rapid.
4	July 23	10 28	1	283	+15	286	+11	5	Slow; across ϵ and ζ Aquilæ.
5	July 27	9 55	1	256	+56	252	+38	18	Rapid; probably a Perseid.
6	July 28	9 7	= ♂	332	+56	6	+51	21	Deep red, red streak, 3 sec.
7	July 28	10 21	1	339	+33	347	+30	9	Rapid.
8	July 28	10 28	>1	346	+13	356	+32	23+	Not wholly visible; quite slow.
9	Aug. 3	9 49	1	340	+24	344	+33	10	Between η and β Pegasi, quite rapid.
10	Aug. 3	11 22	1	19	+30	22	+47	17	Slow; between β and γ Andromedæ.
11	Aug. 3	11 27	1	47	+55	50	+55	3	Rapid; a Perseid; from γ Persei.
12	Aug. 20	8 32	1	155	+72½	137½	+70	5	Slow.
13	Aug. 22	8 59	1	185	+70	170	+68	6	Rapid.
14	Aug. 22	10 2	= ♂	248	+63	230	+77	15	Deep orange; orange trail; 3 sec.
15	Aug. 25	8 59	1	249½	+39	250½	+27	12	Rapid; from η Herculis.
16	Aug. 27	10 4	1	263½	+48	245	+52½	15	Rather slow; an August Lyriad.
17	Aug. 27	10 19	1	245	+56	229	+58	10	Rapid; a Lyriad.
18	Aug. 29	8 46	1	187½	+45	185½	+38½	6	Rapid.
19	Aug. 30	8 32	1	257	+50	252½	+62½	13	Slow; deep orange.
20	Aug. 31	8 35	1	212	+24	202½	+26	9	Slow; near α Boötes.
21	Sept. 1	10 8	1	236	+30	232	+22	8	Rapid; near α Coronæ.
22	Sept. 18	8 29	1	323	−15	325	−20	5	Slow; orange; orange streak.
23	Sept. 20	9 39	1	329	− 2	326	−16	14	Rapid; from near α Aquarii.
24	Sept. 22	7 19	1	289	−15	295	− 2	17	Rapid.
25	Sept. 22	8 33	>♃	2½	−17½	5	−22	5	Vertically; very slow; near β Ceti. deep orange; no trail; 2 sec.
26	Sept. 23	7 18	1	355½	+12½	346	− 6½	15	Rapid.
27	Sept. 23	8 25	1	360	+28	10	+26	10	2 sec.; green.
28	Sept. 23	9 26	>1	42	+56	105	+65	33	Slow; visible 2 sec.; blue.
29	Sept. 27	8 10	1	341½	+16	347	+22	7	Very slow; 1·5 sec.; orange.
30	Sept. 28	9 52	1	49	+ 8	47	− 2	10	Rapid; green.
31	Sept. 29	9 5	1	15	+ 3				Stationary; 1 sec.; approximate.
32	Sept. 29	9 36	1	48	+21	55	+17½	8	Rapid.

ART. XLII.—*Remarks on the General Ocean Circulation;* by SIR WYVILLE THOMSON. From his Address to the Geographical Section of the British Association, at its recent meeting.*

IT was pointed out long ago by Sir Charles Lyell that many of the most marked phenomena of the present physical condition of the globe depend upon the fact that the surface of the world is divided into two hemispheres, one of which contains nearly the whole of the dry land of this world, while the other is almost entirely covered by water. The center of the land hemisphere is somewhere in Great Britain, and the center of the water hemisphere, which includes the southern sea, the South Pacific, whatever antarctic land there may be, Australia, and the southern point of South America, is in this neighborhood of New Zealand. With a full knowledge of the absolute continuity of the ocean we have hitherto been too much in the habit of regarding it as composed of several oceans, each possibly under special physical conditions. All recent observations have, however, shown us that the vast expanse of water which has its center in the southern hemisphere is the one great ocean of the world, of which the Atlantic with the Arctic Sea and the North Pacific are merely northward extending gulfs; and that any physical phenomena affecting obviously one portion of its area must be regarded as one of an interdependent system of phenomena affecting the ocean as a whole.

Shallow as the stratum of water forming the ocean is—a mere film in proportion to the radius of the earth—it is very definitely split up into two layers, which, so far as all questions concerning ocean movements and the distribution of temperature are concerned, are under very different conditions. At a depth varying in different parts of the world, but averaging perhaps 500 fathoms, we arrive at a layer of water at a temperature of 40° F., and this may be regarded as a kind of neutral band separating the two layers. Above this band the temperature varies greatly over different areas, the isothermobathic lines are sometimes tolerably equally distributed, and at other times crowding together towards the surface, while beneath it the temperature almost universally sinks very slowly and with increasing slowness to a minimum at the bottom.

The cause of natural phenomena, such as the movements of great masses of water, or the existence over large areas of abnormal temperature conditions, are always more or less complex, but in almost all cases one cause appears to be so very much the most efficient that in taking a general view all others

* Nature, August 22, 1878.

may be practically disregarded: and speaking in this sense it may be said that the trade-winds and their modifications and counter-currents are the cause of all movements in the stratum of the ocean above the neutral layer. This system of horizontal circulation, although so enormously important in its influences upon the distribution of climate is sufficiently simple. Disregarding minor details, the great equatorial current driven from east to west across the northerly extensions of the ocean by the trade-winds, impinges upon the eastern coasts of the continents. A branch turns northward and circles round the closed end of the Pacific, tending to curl back to the North American coast from its excess of initial velocity; and in the Atlantic, following a corresponding course, the Gulf Stream bathes the shores of Northern Europe, and a branch of it forces its way into the Arctic basin, and battling against the palæocrystic ice, keeps imperfectly open the water-way by which Nordenskjöld hopes to work his course to Behring's Strait. The southern deflections are practically lost, being to a great extent, though not entirely dissipated in the great westerly current of the southern anti-trades.

One of the most singular results of these later investigations is the establishment of the fact that all the vast mass of water, often upwards of 2,000 fathoms in thickness, below the neutral band, is moving slowly to the northward; that in fact the depths of the Atlantic, the Pacific and the Indian Oceans are occupied by tongues of the Antarctic Sea, preserving in the main its characteristic temperatures. The maintenance of a low temperature while the temperature of the floor of the ocean must be higher, and that of the upper layers of the sea greatly higher, is in itself a conclusive proof of steady movement of the water from a cold source; and the fact that the temperature of the lower layers of water, both in the Atlantic and the Pacific, is slightly but perceptibly raised to the northward, while the continuity of every layer with a corresponding layer in the southern sea can be clearly traced, indicates the southern position of that source.

The immediate explanation of this very unexpected phenomenon seems simple. For some cause or other, as yet not fully understood, evaporation is greatly in excess of precipitation over the northern portion of the land-hemisphere, while over the water-hemisphere, and particularly over its southern portion, the reverse is the case; thus one part of the general circulation of the ocean is carried on through the atmosphere, the water being raised in vapor in the northern hemisphere, hurried by upper wind currents to the zone of low barometric pressure in the south, where it is precipitated in the form of snow or rain, and welling thence northward in the deepest channels on

account of the high specific gravity dependent on its low temperature, it supplies the place of the water which has been removed.

The cold water wells northward, but it meets with some obstructions on its way, and these obstructions, while they prove the northward movement, if further proof were needed, bring out another law by which the distribution of ocean temperature is regulated. The deeper water sinks slowly to a minimum at the bottom, so that if we suppose the temperature at a depth of 2,000 fathoms to be 36° F., the temperature at a depth of 3,000 may be, say, 32°. Now, if in this case the slow current meet on its northward path a continuous barrier in the form of a submarine mountain ridge rising to within 2,000 fathoms of the sea-surface, it is clear that all the water below a temperature of 36° will be arrested, and, however deep the basin beyond the ridge may be, the water will maintain a minimum of 36° from a depth of 2,000 fathoms to the bottom. In many parts of the ocean we have most remarkable examples of the effect upon deep-sea temperature of such barriers intersecting cold indraughts, the most marked instance, perhaps, a singular chain of closed seas at different temperatures among the islands of the Malay Archipelago; but we have also a striking instance nearer home. Evaporation is greatly in excess of precipitation over the area of the Mediterranean, and consequently, in order to keep up the supply of water to the Mediterranean, there is a constant inward current through the Straits of Gibraltar from the Atlantic; I need not at present refer to an occasional tidal counter-current. The minimum temperature of the Mediterranean is about 54° F. from a depth of 100 fathoms to the bottom. The temperature of 54° is reached in the Atlantic at the mouth of the Straits of Gibraltar at a depth of about 100 fathoms, so that in all probability future soundings will show that the free water-way through the Straits does not greatly exceed 100 fathoms in depth.

The Depth of the Sea, and the Nature of Modern Deposits.—It seems now to be thoroughly established by lines of trustworthy soundings which have been run in all directions, that the average depth of the ocean is a little over 2,000 fathoms, and that in all probability it nowhere exceeds 5,000 fathoms. Depths beyond 4,000 fathoms are rare and very local, and seem to be usually pits in the neighborhood of volcanic islands. In all the ocean basins there are depressions extending over considerable areas where the depth reaches 3,000 fathoms or a little more, and these depressions maintain a certain parallelism with the axes of the neighboring continents.

Within 300 or 400 miles of the shore, whether in deep or in shallow water, formations are being laid down, whose materials

are derived mainly from the disintegration of shore rocks, and which consequently depend for their structure and composition upon the nature and composition of the rocks which supply their materials. These deposits imbed the hard parts of the animals living on their area of deposition, and they correspond in every way with sedimentary formations with which we are familiar, of every age. In water of medium depths down to about 2,000 fathoms, we have in most seas a deposit of the now well-known globigerina-ooze, formed almost entirely of the shells of foraminifera living on the sea-surface, and which after death have sunk to the bottom. This formation, which occupies a large part of the bed of the Atlantic and a considerable part of that of the Pacific and Southern Seas, is very like chalk in most respects, although we are now satisfied that it is being laid down as a rule in deeper water than the chalk of the Cretaceous period.

In depths beyond 2,500 or 3,000 fathoms no such accumulations are taking place. The shores of continents are usually too distant to supply land detritus, and although the chalk-building foraminifera are as abundant on the surface as they are elsewhere, not a shell reaches the bottom; the carbonate of lime is entirely dissolved by the carbonic acid contained in the water during the long descent of the shells from the surface. It therefore becomes a matter of very great interest to determine what processes are going on, and what kind of formations are being laid down in these abyssal regions, which must at present occupy an area of not less than ten millions of square miles.

The tube of the sounding instrument comes up from such abysses filled with an extremely fine reddish clay, in great part amorphous, but containing, when examined under the microscope, a quantity of distinctly recognizable particles, organic and inorganic. The organic particles are chiefly siliceous, and for the most part the shells or spines of radiolarians which are living abundantly on the surface of the sea, and apparently in more or less abundance at all depths. The inorganic particles are minute flakes of disintegrated pumice, and small crystalline fragments of volcanic minerals; the amorphous residue is probably principally due to the decomposition of volcanic products, and partly to the ultimate inorganic residue of decomposed organisms. There is ample evidence that this abyssal deposit is taking place with extreme slowness. Over its whole area, and more particularly in the deep water of the Pacific, the dredge or trawl brings up in large numbers nodules very irregular in shape, consisting chiefly of sesquioxide of iron and peroxide of manganese, deposited in concentric layers in a matrix of clay, round a nucleus formed of a shark's tooth, or a piece of

bone, or an otolith, or a piece of siliceous sponge, or more frequently a fragment of pumice. These nodules are evidently formed in the clay, and the formation of the larger ones and the segregation of their material must have taken a very long time. Many of the sharks' teeth to which I have alluded as forming the nuclei of the nodules, and which are frequently brought up uncoated with foreign matter, belong to species which we have every reason to believe to be extinct. Some teeth of a species of *Carcharodon* are of enormous size, four inches across the base, and are scarcely distinguishable from the huge teeth from the Tertiary beds of Malta. It is evident that these semi-fossil teeth, from their being caught up in numbers by the loaded line of the trawl, are covered by only a very thin layer of clay.

Another element in the red clay has caused great speculation and interest. If a magnet be drawn through a quantity of the fine clay well diffused in water, it will be found to have caught on its surface some very minute magnetic spherules, some apparently of metallic iron in a passive state, and some of metallic nickel. From the appearance of these particles, and from the circumstance that such magnetic dust has been already detected in the sediment of snow-water, my colleague Mr. Murray has a very strong opinion that they are of cosmic origin—excessively minute meteorites. They certainly resemble very closely the fine granules which frequently roughen the surface of the characteristic skin of meteorites, and from their composition and the circumstances under which they are found there is much to be said in favor of this view. I cannot, however, hold it entirely proved; there can be little doubt, from the universal presence of water-logged and partially decomposed pumice on the bottom, and from the constant occurrence of particles of volcanic minerals in the clay, that the red clay is formed in a great measure by the decomposition of the lighter products of submarine volcanoes drifted about by currents, and finally becoming saturated with water and sinking; and it is well known that both iron and nickel in a metallic state are frequently present in minute quantities in igneous rocks. I think it is conceivable that the metallic spherules may be derived from this source.

So far as we can judge, after a most careful comparative examination, the deposit which is at present being formed at extreme depths in the ocean does not correspond, either in structure or in chemical composition, with any known geological formation; and, moreover, we are inclined to believe, from a consideration of their structure and of their imbedded organic remains, that none of the older formations were laid down at nearly so great depths—that, in fact, none of these have any-

thing of an abyssal character. These late researches tend to show that during past geological changes abyssal beds have never been exposed, and it seems highly probable that until comparatively recent geological periods such beds have not been formed.

It appears now to be a very generally received opinion among geologists—an opinion which was first brought into prominence by Professor Dana—that the "massive" eruptions which originated the mountain chains which form the skeleton of our present continents, and the depressions occupied by our present seas date from the secular cooling and contraction of the crust of the earth—from a period much more remote than the deposition of the earliest of the fossiliferous rocks—and that during the period chronicled by the successive sedimentary systems, with many minor oscillations by which limited areas have been alternately elevated and depressed, the broad result has been the growth by successive steps of the original mountain chains and the extension of the continents by their denudation, and the corresponding deepening of the original grooves. If this view be correct—and it certainly appears to me that the reasoning in its favor is very cogent—it is quite possible that until comparatively recent times no part of the ocean was sufficiently deep for the formation of a characteristic abyssal deposit.

Time will not allow me even to allude to the interesting results which have been obtained from the determination of the density of sea water from different localities and different depths, and from the analysis of sea water and its contained gases, and perhaps these results have been scarcely sufficiently worked out as yet to afford safe bases for generalization. I must, however, say a few words as to certain additions which have been made to our knowledge of the two hitherto impregnable strongholds of the frost, the regions round the North and South Poles.

The Arctic Regions.—The question which has of late held the most prominent place in all discussions about the conditions of the Arctic Regions, particularly since the voyage of Dr. Hayes, is whether it is possible that there can be, at all times or at any time, anything in the form of an open Polar sea. This question seems now to be virtually settled, and in the most unsatisfactory manner imaginable. There can be no doubt that in the year 1871 Count Wilczek, in the schooner *Isbjörn*, found the sea between Novaya Zemlya and Spitzbergen nearly free from ice, and that the same sea presented to Weyprecht and Payer in the following year a dangerous stretch of moving and impenetrable pack. There can be no doubt that in the year 1861 Dr. Hayes gazed over an expanse of open water where, in 1875–76, Capt. Nares studied the conditions of palæocrystic ice. It is evident, therefore, that the Polar basin, or at all events

such portions of it as have been hitherto reached, is neither open sea nor continuous ice, but a fatal compromise between the two, an enormously heavy pack formed by the piling up and crushing together of the floe of successive years, in frequent movement, breaking up and shifting according to the prevailing direction of the wind, and leaving open, now here and now there, lanes and vistas of deceptive open water which may be at any moment closed and converted into a chaotic mass of hurling floe-bergs by a hurricane from another direction. It seems, however, that in certain seasons there is more open water in the direction of Grinnell's Land and Smith's Sound than in others, and that there are also years comparatively favorable for the northward route following the lead of Franz-Josef Land; and there seem now to be only two plans, one nearly as hopeless as the other, to choose between in any future attempt—either to establish several permanent Polar stations, as proposed by Lieut. Weyprecht, and already initiated at one point, so far as preliminaries are concerned, by Capt. Tyson and Capt. Howgate, and to seize the opportunity of running north in early autumn from the station where the sea appears most open, or to run as far north as possible at enormous expense, with a great force of men and abundance of provisions and paraffin oil, and push northward during the arctic winter by a chain of communicating stations with ice-built refuge huts. It seems possible that in a cold season, with the pack in the condition in which Markham found it in 1876, some progress might be made in this way if it were conceivable that the end to be gained was worth the expenditure of so much labor and treasure.

The Antarctic Regions.—But little progress has been made during the last quarter of a century in the actual investigation of the conditions of that vast region which lies within the parallel of 70° S. Some additional knowledge has been acquired, and the light which recent inquiries have thrown upon the general plan of ocean circulation and the physical properties of ice, have given a new direction to what must partake for some time to come of the nature of speculation.

From information derived from all sources up to the present time, it may be gathered that the unpenetrated area of about 4,700,000 square miles surrounding the South Pole is by no means certainly a continuous "Antarctic Continent," but that it consists much more probably partly of comparatively low continental land, and partly of a congeries of continental (not oceanic) islands, bridged between and combined, and covered to the depth of about 1,400 feet, by a continuous ice-cap; with here and there somewhat elevated continental chains, such as the groups of land between 55° and 95° W., including Peter

the Great Island and Alexander Land, discovered by Billingshausen in 1821, Graham Land and Adelaide Island, discovered by Biscol in 1832, and Louis Philippe Land by D'Urville in 1838, and at least one majestic modern volcanic range discovered by Ross in 1841 and 1842, stretching from Balleny Island to a latitude of 78° S., and rising to a height of 15,000 feet. It seems, so far as is at present known, that the whole of the antarctic land, low and high, as well as the ice-cap of which a portion of the continuous continent may consist, is bordered to some distance by a fringe of ice, which is bounded to seaward by a perpendicular ice-cliff, averaging 230 feet in height above the sea-level. Outside the cliff a *floe*, which attains near the barrier a thickness of about twenty feet, and in some places by piling a considerably greater thickness, extends northward in winter to a distance varying according to its position with reference to the southward trending branches of the equatorial current; and this floe is replaced in summer by a heavy drifting pack with scattered icebergs. Navigating the Antarctic Sea in the southern summer, the only season when such navigation is possible, it has been the opinion of almost all explorers, that after forcing a passage through an outer belt of heavy pack and icebergs, moving as a rule to the northwestward, and thus fanning out from the ice-cliff in obedience to the prevailing southeasterly winds, a band of comparatively clear water is to be found within.

Several considerations appear to me to be in favor of the view that the area round the South Pole is broken up and not continuous land. For example, if we look at a general ice-chart we find that the sea is comparatively free from icebergs, and that the deepest notches occur in the "Antarctic Continent" at three points, each a little to the eastward of south of one of the great land masses. Opposite each of these notches a branch of the equatorial current is deflected southward by the land, and is almost merged in the great drift-current which sweeps round the world in the Southern Sea before the westerly anti-trades. But while the greater portion of the Brazilian current, the East Australian current, and the southern part of the Agulhas current are thus merged, they are not entirely lost; for at these points of junction with the drift-current of the westerlies, the isobathytherms are slightly deflected to the southward, and it is opposite these points of junction that we have comparatively open sea and penetrable notches in the southern pack. But we have not only the presumed *effect* of this transfer of warmer water to the southward; we were able to detect its presence in the *Challenger* by the thermometer. Referring to the result of a serial temperature sounding on February 14, 1874, with a surface temperature of 29° F. at a

depth of from 300 to 400 fathoms, there is a band of water at a temperature of more than half a degree above the freezing-point. That this comparatively warm water is coming from the north there is ample proof. We traced its continuity with a band at the same depth gradually increasing in warmth to the northward, and it is evident that its heat can be derived from no other source, and that it must be continually receiving new supplies, for it is overlaid by a band of colder water, tending to mix with it by convection.

It is, of course, possible that these warm currents may by coincidence be directed toward those notches already existing in a continental mass of land; but such a coincidence would be remarkable, and there is certainly a suggestion of the alternative that the "continent" may consist to so great an extent of ice as to be liable to have its outline affected by warm currents.

In high southern latitudes it seems that all the icebergs are originally tabular, the surface perfectly level and parallel with the surface of the sea, a cliff about 230 feet high bounding the berg. The top is covered with a layer of the whitest snow; now and then a small flock of petrels take up their quarters upon it, and trample and soil some few square yards, but after their departure one of the frequent snow showers restores it in a few minutes to its virgin whiteness. The upper part of the cliff is pale blue, which gradually deepens toward the base. When looked at closely the face of the cliff is seen to be traversed by a delicate ruling of faint blue lines, the lines being more distant from one another above and becoming gradually closer. The distance between the well-marked lines near the top of a berg may be of a foot or even more, while near the surface of the water it is not more than two or three inches, and the space between the blue lines have lost their dead whiteness and have become hyaline or bluish. The blue lines are very unequal in their strength and in their depth of coloring; sometimes a group of very dark lines gives a marked character to a part of a berg. Between the stronger blue lines near the top of the cliff a system of closer lines may be observed, marking the division of the ice by still finer planes of lamination; but in the narrower spaces near the water-line they are blended and lost. The blue lines are the sections of sheets of clear ice; the white intervening bands are the sections of layers of ice where the particles are not in such close contact —ice probably containing some air.

The stratification in all these icebergs is, I believe, originally horizontal and conformable, or very nearly so. In many, while melting and beating about in the sea, the strata become inclined at various angles, or vertical or even reversed; in many they are traversed by faults, or twisted, or contorted, or displaced;

but I believe that all deviations from a horizontal arrangement are due to changes taking place in the icebergs themselves.

I think there can be no doubt, from their shape and form, and their remarkable uniformity of character, that these great table-topped icebergs are prismatic blocks riven from the edge of the great antarctic ice-sheet. I conclude, therefore, that the upper part of the iceberg, including by far the greater part of its bulk, and culminating in the portion exposed above the surface of the sea, was formed by the piling up of successive layers of snow during the period, amounting perhaps to centuries, during which the ice-cap was slowly forcing its way over the low land, and out to sea over a long extent of gentle slope, until it reached a depth considerably beyond 200 fathoms, when the lower specific weight of the ice caused an upward strain which at length overcame the cohesion of the mass, and portions were rent off and floated away. The icebergs when they are first dispersed float in from 200 to 250 fathoms; when, therefore, they have been drifted to latitudes of 65° or 64° south, the bottom of the berg, the surface which forced itself glacier-like over the land, just reaches the layer at which the temperature of the water distinctly rises; and is rapidly melted, and the pebbles and land *débris* with which it is more or less charged are precipitated. That this precipitation takes place all over the area where the icebergs are breaking up, constantly and to a considerable extent, is evident from the fact that the matter brought up by the sounding instrument and the dredge is entirely composed of such deposits from ice; for diatoms, foraminifera and radiolarians are present on the surface in large numbers, and unless the deposit from the ice were abundant it would soon be covered and masked by the skeletons of surface organisms.

The curious question now arises, what is the cause of the uniform height of the southern icebergs—that is to say, what is the cause of the restriction of the thickness of the free edge of the ice-cap to 1,400 fathoms? I have mentioned the gradual diminution in thickness of the strata of ice in a berg from above downward. The regularity of this diminution leaves it almost without a doubt that the layers observed are in the same category, and that therefore the diminution is due to subsequent pressure or other action upon a series of beds, which were at the time of their deposition nearly equally thick. About 60 or 80 feet from the top of an iceberg, the strata of ice a foot or so in thickness, although of a white color and thus indicating that they contain a considerable quantity of air, are very hard, and the specific weight of the ice is not much lower than that of layers three inches thick nearer the water-line of the berg. The upper layers have been manifestly produced by falls of snow after the berg has been detached.

Now it seems to me that the reduction in thickness cannot be due to compression alone, but that a portion of the substance of the lower layers must have been removed. It is not easy to see why the temperature of the earth's crust, under a widely extended and practically permanent ice-sheet of great thickness, should ever fall below the freezing-point; and it is a matter of observation that at all seasons of the year vast rivers of muddy water flow into the frozen sea from beneath the great glaciers which are the issues of the ice-sheet of Greenland. Ice is a very bad conductor, so that the cold of winter cannot penetrate to any great depth into the mass. The normal temperature of the surface of the earth's crust, at any point where it is uninfluenced by cyclical changes, is at all events above the freezing-point, so that the temperature of the floor of the ice-sheet would certainly have no tendency and fall below that of the stream passing over it. The pressure upon the deeper beds of the ice must be enormous at the bottom of an ice-sheet 1,400 feet in thickness—not much less than a quarter of a ton on the square inch. It seems, therefore, probable that under the pressure to which the body of ice is subjected a constant system of melting and regelation is taking place, the water passing down by gravitation from layer to layer until it reaches the floor of the ice-sheet, and finally working out channels for itself between the ice and the land, whether the latter be subaërial or submerged.

I should think it probable that this process, or some modification of it, may be the provision by which the indefinite accumulation of ice over the antarctic continent is prevented and a certain uniformity in the thickness of the ice-sheet maintained—that in fact ice at the temperature at which it is in contact with the surface of the earth's crust within the antarctic regions cannot support a column of itself more than 1,400 feet high without melting. It is suggested to me by Professor Tait that the thickness of the ice-sheet very probably depends upon its area, as the amount of melting through squeezing and the earth's internal heat, will depend upon the facility of the escape of the water. The problem is, however, an exceedingly complex one, and we have perhaps scarcely sufficient data for working it out.

The Fauna of the Deep Sea.—I can scarcely regret that it is utterly impossible for me on this occasion to enter into any details with regard to the relations of the abyssal fauna, the department of the subject which has naturally had for me the greatest interest. Recent investigations have shown that there is no depth limit to the distribution of any group of gill-bearing marine animals. Fishes, which, from their structure and from what we know of the habits of their congeners, must certainly

live on the bottom, have come up from all depths, and at all depths the whole of the marine invertebrate classes are more or less fully represented. The abyssal fauna is of a somewhat special character, differing from the fauna of shallower water in the relative proportions in which the different invertebrate types are represented. It is very uniform over an enormously extended area, and in this respect it fully confirms the anticipations of the great Scandinavian naturalist, Lovén, communicated to this Association in the year 1844. It is a rich fauna, including many special genera and an enormous number of special species, of which we, of course, know as yet only a fraction; but I do not think I am going too far in saying that from the results of the *Challenger* expedition alone the number of known species in certain classes will be doubled. The relations of the abyssal fauna to the faunæ of the older Tertiary and the newer Mesozoic periods are much closer than are those of the faunæ of shallow water; I must admit, however, that these relations are not so close as I expected them to be—that hitherto we have found living only a very few representatives of groups which had been supposed to be extinct. I feel, however, that until the zoological results of these later voyages, and especially those of the *Challenger*, shall have been fully worked out, it would be premature to commit myself to any generalizations.

I have thus attempted to give a brief outline of certain defensible general conclusions, based upon the results of recent research. Some years ago, certain commercial enterprises, involving the laying of telegraph cables over the bed of the sea, proved that the extreme depths of the ocean were not inaccessible. This somewhat unexpected experience soon resulted in many attempts, on the part of those interested in the extension of the boundaries of knowledge, to use what machinery they then possessed to determine the condition of the hitherto unknown region. This first step was naturally followed by a development of all appliances and methods bearing upon the special line of research; and within the last decade the advance of knowledge of all matters bearing upon the physical geography of the sea has been confusingly rapid—so much so, that at this moment the accumulation of new material has far outstripped the power of combining and digesting and methodizing it. This difficulty is greatly increased by the extreme complexity of the questions, both physical and geological, which have arisen. Steady progress is, however, being made in both directions, and I trust that in a few years our ideas as to the condition of the depth of the sea may be as definite as they are with regard to regions to which we have long had ready access.

ART. XLIII.—*Notes on Antimony Tannate.* No. II; by ELLEN SWALLOW RICHARDS and ALICE W. PALMER.

THE next point of interest was to determine whether the method of titration as given in the preceding paper (this Journal, p. 196) was applicable to tannin-holding substances other than nut-galls and sumac. The following tests were made for this purpose:

	Tannin. Per cent.
Leaves of sweet-fern (*Comptonia asplenifolia*) from near Boston, gathered the middle of May	7·56
The same, gathered on the Kennebec River, Maine, the last of July	8·00
Sample of ground hemlock-bark from Vermont	7·07
Sample of catechu	29·70
Sample of kino	41·50
Crushed quercitron bark	7·00
Congo tea	4·60
Cinchona flavor	9·60
Ground cloves	7·03
Chestnut-oak from Careyville, Tenn.	3·00

We also prepared a quantity of antimony-tannate from each of these substances in the same manner as we had prepared it from commercial tannin and sumac. The composition is given as follows:

	Sb. Per cent.	C. Per cent.	H. Per cent.
Sweet-fern (May)	15·30	45·09	3·40
Sweet-fern (July)	15·06	44·90	3·90
Quercitron	12·80	49·50	3·42
Chestnut-oak	15·50	47·51	3·63
Cloves	12·50	43·30	3·09
Hemlock-bark, No. I.	13·60	51·02	3·85
Hemlock-bark, No. II.	13·50	49·86	
Catechu	13·70	51·13	3·84
Kino	15·00	50·71	3·72
Cinchona flava	11·20	53·56	4·56
Congo tea	11·40	47·30	4·00

These analyses showed that the composition of the precipitate was influenced by one of two causes: either the formula of the so-called tannin which united with the antimony contained more C and H than di-gallic acid,—that is, it must be something like $SbOC_{36}H_{33}O_{17}$ or $Sb_2(C_{25}H_{21}O_{12})_3$—or the antimony-tannate, which was formed in the solution, acted as a mordant, and carried down with it coloring matters which might or might not affect the titration, but which did affect the combustion.

To determine how far this latter cause could be held responsible, we prepared antimony tannate from the sample of tannin

which we used for all our experiments, and having washed by decantation so as to keep the gelatinous precipitate in the best condition for absorbing color, we treated solutions of several of these substances with a quantity of antimony tannate corresponding to the estimated quantity of tannin contained in the solution, so as to have the conditions the same as in the previous precipitations; in one case we increased the amount of antimony tannate. The composition of the antimony tannate thus treated in the different solutions, together with the average composition of antimony tannate as we have already obtained it from tannin, sumac and nut-galls is given as follows:

	Sb. Per cent.	C. Per cent.	H. Per cent.
Sweet-fern + antimony tannate	15·70	46·21	3·73
Quercitron + antimony tannate	9·54	45·90	3·80
Hemlock + antimony tannate	-	63·30	3·60
Hemlock+five times the required amount of antimony tannate	13·40	43·40	3·90
Antimony-tannate	20·00	38·21	2·86

In the case of sweet-fern and quercitron, the results are very nearly those obtained by direct precipitation with tartar emetic. The possible reason for this will be considered later.

We were greatly surprised by the behavior of the solution of hemlock-bark. In all cases after treating the solution with the previously prepared antimony-tannate, we precipitated the remaining tannin by tartar emetic as usual, and noted the quantity required as compared with that required for the precipitation of tannin in the titration. The sweet-fern and quercitron gave a precipitate about one-third less than that from the original solution. In the case of hemlock there was scarcely a trace of a precipitate, showing that the antimony tannate had dragged down or united with all the substance which had been supposed to be tannin.

In order further to test the character of the supposed coloring matter in these substances, we made a series of trials with mordanted yarn. A brown-red color was obtained from hemlock on wool mordanted with tin chloride, and on cotton mordanted with alumina. A brilliant yellow color nearly equal to that from quercitron was obtained from sweet-fern on both the wool and the cotton.

We then tested solutions of all the substances upon which we had been working with cloth mordanted in the usual way for calico-printing (with iron and alumina in alternate stripes), in order to show the presence of tannin and coloring matter at the same time. This test divided the substances into two classes, the one showing the deep black of tannin on the iron stripe, and a yellow more or less intense on the alumina; the other giving on the iron stripe a faint brownish-black, corre-

sponding in dullness to that produced by gallic acid, and on the alumina a dull reddish-brown. To the first class belong nut-galls, sumac, sweet-fern leaves, bark of quercitron, black oak, white oak and chestnut oak and bearberry leaves; to the other, hemlock, catechu, kino, fever bark, cinchona bark and congo tea. For our further investigation we took sweet-fern as the type of the former, and hemlock as that of the latter class.

The yellow in sweet-fern seems closely allied to, if not identical with the quercetin derived from oak-bark. A solution of sweet-fern guarancined (i. e., boiled with very dilute sulphuric acid), behaves like a solution of quercitron-bark,—a black gummy mass being formed, and the solution depositing yellow flakes which dye intensively.

Two pieces of cloth of equal size, the one dyed with one gram of sweet-fern leaves, the other with one gram of quercitron-bark, showed rather more tannin and less yellow for the sweet-fern, and more yellow and less tannin for the quercitron.

A single trial of the amount of yellow in sweet-fern, by weighing the antimony-tannate which had carried down the yellow with it, and which had been added in known quantity gave 2·5 per cent, and the amount of tannin in the filtrate had decreased about three, of the eight per cent. This indicates that the antimony combines with a portion of the coloring matter, as well as with the tannin. This is further shown by the fact that the quercetin-like color obtained by guarancining was precipitated by antimony. The formula of this portion of the color must be very near to that of di-gallic acid, since the per cent of C and H in the precipitate from sweet-fern after the original solution had been treated with antimony tannate and the tannin then precipitated by tartar emetic was C 44·32 and H 3·89, and the composition of the precipitate when tartar emetic had been added directly to the solution without previous treatment with the antimony tannate was C 44·9 per cent and H 3·9 per cent.

Heppe (Die chemischen Reactionen) gives the formula of quercetin as $C_{27}H_{18}O_{12}$ and that of quercetin acid as $C_{15}H_{10}O_7$, which, corresponding to our formula of antimony tannate, would give respectively:

	Sb.	C.	H.
$Sb_2(C_{27}H_{18}O_{12})_3+6H_2O$	12·52 pr. ct.	50·00	3·08
$Sb_2(C_{15}H_8O_7)_3+6H_2O$	19·49	43·13	2·87
Antimony-tannate,			
$Sb_2(C_{14}H_8O_9)_3+6H_2O$	18·59	38·41	2·74

The result of this is that the process of titration with tartar emetic, when applied to the class of substances holding this yellow coloring principle, would give too high results. We

have not yet succeeded in isolating this yellow coloring matter unchanged, in order to test its effect on the accuracy of the iodine process or Löwenthal's method.

As to the brown-red obtained from the fresh hemlock, it seems to belong to a different class of substances. It is precipitated by gelatine, is acted on by iodine, is precipitated by antimony, and on fusion with potassium hydrate it is decomposed, and a substance is formed which blackens the iron stripe like tannin. We have not yet obtained a sufficient quantity to determine its composition or to deduce a theory for its relation to di-gallic acid. Our experiments go to show that the red-brown is decomposed in the slow process of fermentation, and the iron-blackening substance thus formed may possibly be the agent of the tanning.

Massachusetts Institute of Technology, Woman's Laboratory, August, 1878.

ART. XLIV.—*On a Pseudomorph after Anorthite, from Franklin, New Jersey;* by Professor W. T. RŒPPER.

ON the northern part of Mine Hill, at Franklin, New Jersey, there are found, partly in detached pieces scattered over the surface, or in the fences surrounding the fields of the miners, and in place in a stratum of white crystalline limestone, pseudomorphs that have the form of anorthite, accompanied by a dark hornblende, and numerous small, very brilliant and highly modified, clove-brown crystals of sphene. The outside of the anorthite crystals, the larger of which are generally more or less cavernous, is invariably "candied" over by exceedingly small, brilliant prismatic crystals.

The crystals, from one-eighth to two or three inches in size, are distinctly feldspathic in habit, the prevailing faces, in the order of their dominancy, being: O, i-$\breve{i}$, I, 2-$\breve{i}$, 2-$\bar{i}$ and 1. Owing to the above mentioned micro-crystalline character of the surface and consequent want of reflection, the angles can be measured only with the application-goniometer. The following angles are averages of a number of tolerably concordant measurements:

$O \wedge i$-$\breve{i}$ over 2-$\breve{i}$	$\frac{3}{3}$	85° 33′,	difference of extremes, 20′
$O \wedge I'$	$\frac{3}{3}$	114 32,	" " 12′
$O \wedge I$	$\frac{3}{3}$	110 32,	" " 5′
$O \wedge$ 2-$\bar{i}$	$\frac{5}{5}$	98 56,	" " 40′
$I \wedge I'$		120 50,	
$O \wedge 2'$-$\breve{i}$		133 10,	
$O \wedge 1$		122	

$O \wedge i$-$\breve{i}$ however is in some crystals as high as 88°. Cleavage O and i-$\bar{i}$ easy and distinct, generally dull, but the basal cleavage occasionally sub-pearly.

H.=6; G.=3·06–3·10. Color light bluish green to greenish white.

Fusible with some difficulty to a slightly vesicular glass. Partially attacked by hydrochloric acid without gelatinizing.

				Oxygen.	
Composition:	Silica	39·73		21·19	4
	Alumina	32·53	15·16	16·00	3
	Iron sesquioxide	2·80	·84		
	Magnesia	1·44	·57	5·80	1
	Lime	14·93	4·27		
	Soda	·43	·11		
	Potash	5·01	·85		
	Ignition	3·65			
		100·52			

I have to remark that I have reason to consider the magnesia too high. There is probably only a trace. If so, the oxygen ratio would be 21·19 : 16 : 5·23, still nearer the anorthite ratio of 4 : 3 : 1.

Though the crystalline form and the composition would make it a lime-potash anorthite, the high specific gravity and the water point to a change or alteration of its original constitution. The nature of this change is clearly shown by a thin section, which Mr. G. W. Hawes was so kind as to make for me. When observed under the microscope, it shows that the mineral is composed of a congeries of small crystals, which produce no change of color under the revolution of the polarizer. The change seems therefore to consist in an internal molecular re-arrangement of part of the constituents of the original anorthite, with the introduction of potash and of some water, whereby its specific gravity was raised to the above-mentioned figure. The minute crystals coating the pseudomorphs may possibly be the actual crystals of the new mineral, which on the surface were able to develop their form. What the latter actually are it is impossible to determine.*

Bethlehem, Pa., Sept. 16, 1878.

* In the Report of Mr. G. W. Hawes on the "Mineralogy and Lithology of New Hampshire," its author gives the following analysis of altered crystals of anorthite of large size, from "diabase," at East Hanover, in that State: Silica 52·52, alumina 30·05, iron sesquioxide 1·10, magnesia 0·30, lime 2·20, soda 3·77, potash 7·11, water 2·67=99·72; G.=2·96. It is a potash-bearing pseudomorph, like that described by Rœpper, with similarly high specific gravity; but instead of having the removed calcium replaced by an *equivalent* proportion of alkali metals, so that the anorthite ratio remains, there is a large loss, as Mr. Hawes states. He recognizes a relation in density to the saussurites. But while this is right, both of these pseudomorphs are removed from the saussurites of euphotide, hitherto studied, by being potash species. The above analysis gives the quantivalent ratio for the protoxides, sesquioxides, and silica, 1 : 5 : 9·5; or, if the water is included in the protoxides, 1 : 2·7 : 5·3. J. D. D.

ART. XLV.—*Upon the Relative Agency of Glaciers and Sub-Glacial Streams in the Erosion of Valleys*;* by Professor W. H. NILES.

IN some remarks† which I made at a meeting of this Society in April, 1873, I stated that my observations among the glaciers of the Alps during the previous summer had led me to the conclusion "that glaciers were not the principal agents in the excavation of valleys." I have since had the opportunity of spending two summers more among those glaciers, and the observations which I made have not only confirmed my previous conclusion, but they have also furnished me additional evidences of the excavating power of sub-glacial streams. This time I was more successful in getting underneath the ice than before, particularly upon the right side of the Great Aletsch Glacier where it passes the cliff near the Bell Alp Hotel. The way glaciers usually move over the ordinary *roches moutonnées*, bridging the hollows between them without conforming to all the inequalities of surface, has been made so well known that additional description is unnecessary here. Under these conditions the glacier does not act upon the lowest surfaces of rock beneath it, and these show by their roughness and irregularity that they were not shaped by its action. It, therefore, becomes evident that in such places some power must have acted or is now at work lower than the surfaces upon which the glacier moves.

Under the edge of the Great Aletsch Glacier I observed in a few places, that pieces were being broken from the lee edges of the *roches moutonnées* by the pressure concentrated upon certain stones or bowlders which had reached these edges in their progress under the ice, but I was not successful in my search for like phenomena in connection with other glaciers. But this action, even if we could suppose it to be sufficiently common, would serve to break away only the same prominent portions of the rock which the glacier abrades.

The ice of the glacier, however, is sufficiently plastic to conform to certain kinds of irregularities of surface, and of one of these there are good examples at the above-mentioned locality. There are long, narrow ridges, the trends of which are the same as the strike of the rock and nearly parallel with the direction of the motion of the glacier. A longitudinal section of one of these ridges gave an outline like that of an elongated *roche moutonné*, while a transverse section showed quite a regularly

* From the Proceedings of the Boston Society of Natural History, vol. xix, pp. 330–336, March 20, 1878.

† Proceedings of the Boston Society of Natural History, vol. xv, pp. 378–381.

corrugated surface. These corrugations originated in the bedded structure of the rock, the upturned edges having been rounded and smoothed by the action of the glacier. The ice had time enough to conform to these longitudinal furrows and ridges as it flowed over them lengthwise; and in August, 1876, as it passed the lee end of a ridge, it preserved the mould of the profile so perfectly that for more than twenty feet the blue arch presented a series of parallel furrows, like the flutings of a Doric column.* I also observed many other examples of the same kind, though none so regularly and beautifully perfect.

There was there at that time another highly interesting and instructive exhibition of glacial action. Within a few feet of the down-stream end of one of these elongated *roches moutonnées* and upon its crest, there was a bowlder fully three feet in diameter, which evidently had been slowly moving along this ridge for some distance, probably from its upper end. There were two sides of this block of stone which were not incased in ice, viz., the lower one resting upon the rock, and the one facing down the glacier. From the lower end of the ridge of rock I looked at the bowlder through a tunnel of pure, blue ice, which was continued as a deep furrow in the under surface of the glacier for fully thirty feet from its beginning. As this was produced by the ice moving over and beyond the bowlder, it was evident that the ice was moving more rapidly than the stone. I afterwards found other examples of the same kind, but none so favorably situated for a striking exhibition of this property of ice. It will be understood that these stones were sufficiently below the upper surface of the glacier to be removed from the effects of the ordinary changes in the temperature of the atmosphere. Although stones which are exposed to such changes may be frozen into the ice at the edges of the glaciers, yet I believe these were so situated as to correctly represent the conditions and movements of those at still greater depths. If this is correct, and I believe it is, it follows that such fragments of rock are not rigidly held in fixed positions in the under surfaces of glaciers and carried irresistibly along at the same rate, but that the constantly melting ice actually flows over them, and that their motion is one of extreme slowness, even when compared with the motion of the glacier itself.†

* I see by quotations from the "Nouvelles Excursions et Séjours dans les Glaciers et les hautes règions des Alpes," by Professor E. Desor, that he there described similar features which he observed in connection with the Aar Glacier in 1844, but I have not been able to obtain a copy of the work for examination.

† In an article in the Geological Magazine, Decade II, vol. iii, 1876, published during the same season that I was making these observations, and which I had not then seen, being away from home, Rev. T. G. Bonney clearly states the same conclusion, presenting as evidences the appearances of certain bowlders observed by him in 1875, near the terminations of the Glacier des Bois and the Glacier

If this is granted, it must then be admitted that the abrading power of glaciers is much less than if the fragments of rock were usually firmly set in the ice. This is one of the many reasons which I have for believing that the erosive power of glaciers is not sufficient, in itself alone, to account for the excavation of those valleys in which they are found.

Among the phenomena which attract the attention and obstruct the progress of the explorer under a glacier, is the abundance of streams. A short distance below the edge of the glacier the ice is constantly melting, and in every place accessible to the observer the water falls, usually in large drops but sometimes in streamlets. Thus the surfaces not covered by the ice are exposed to a constant fall of water, which, first forming numerous rivulets, soon collects in small and rapid streams. The dropping of the water and the rushing of the torrents, the frequent slipping of smaller fragments of stone which have been started by the rivulets and the occasional tumbling or plunging of a larger mass, the incidental cracking of the glacier and the frequent crash of pieces of falling ice, all unite in impressing upon the listener that this is a busy place. Where the glaciers rest upon the upper portions of the *roches moutonnées*, the streams are formed in the hollows between them which the ice does not fill; therefore, under such conditions their erosive power is exercised upon those lower portions of the rock-surface which are not effected by the movements of the glacier.

In estimating the erosive power of a stream we must take into consideration, not only its volume and velocity, but also the more important factor of the materials with which it is charged. The importance of this is well illustrated by the modern appliance called the sand-blast, in which it is not the violence of the current of air or steam but the sand which it carries with it, which cuts away the surfaces of stones, metals and glass with such astonishing rapidity. Sometimes this element has been overlooked, as, for example, when it has been argued that because pure water may rush violently over a rock for a long period without producing any perceptible change, therefore, the valleys which now are or formerly were occupied by glaciers must have been excavated by the ice rather than by the streams below it. A sub-glacial stream, considered as an agent of erosion, should never be compared with a stream of pure water. All of the streams beneath a glacier are charged with small, angular fragments of stone, such as glaciers transport in immense quantities. Any one who has walked over the middle and lower portions of a glacier in summer has not

d'Argentière. I do not learn from what he has written, however, that he saw the ice flowing over stones in the manner I have here described. It is, therefore, my pleasure to have witnessed what I consider to be a proof of the accuracy of the conclusion which Professor Bonney ably drew from other sources.

failed to notice the small fragments of stone which often darken and sometimes cover the surface. When these are examined they are found to be sharply angular; and if the examination is extended to the medial and lateral moraines, they will be found to contain immense quantities of similar materials. These small fragments, as well as large ones, find their way into the sub-glacial streams, in which by the sharpness of their angles they become most effective instruments in the work of erosion. The materials transported by ordinary streams, even when swollen by heavy rains, are of a different nature. The small stones and gravels which they receive are usually more or less rounded, while the finer materials are chiefly loam, clay, soil, or well-worn sand. The erosive power of a current carrying such old, worn, and often soft materials, is much less than that of one charged with the new and sharp instruments of the sub-glacial streams; hence the denuding agency of the latter should not be estimated by observations upon the former.

The excavating power of these streams is shown in the number of pot holes which they produce. The steepness and irregularity of their courses, the abundance of water with stones and sand, and in many places the presence of ice causing gyratory movements of the water, make these streams peculiarly efficient in this work. Sometimes these pot-holes succeed each other so closely in the course of the stream, that as they increase in size they unite and form a deep, narrow gorge, whose walls present a succession of their concave surfaces.

Furthermore, the ice of the glaciers often exercises a controlling influence upon the positions and courses of these streams. It is not uncommon to find a stream flowing along the edge of the glacier considerably below its surface, in a channel one side of which is ice and the other side rock. In such instances the streams are often supported by the ice at a considerable elevation above the bottom of the valley where they would otherwise be. The power which a glacier may have for preventing water from flowing directly into the lower portion of its valley, is well illustrated by the Märjelen See, a lake which owes its existence to the ice-wall of the side of the Great Aletsch Glacier which forms one end of the basin which it occupies.

The lateral streams above described are abundantly supplied with small and large pieces of stone from the lateral moraines, and they thus become agents in the erosion of the sides of the valleys. It will probably be remarked that such streams must naturally erode the ice more rapidly than the rock, but it must be remembered that the ice is constantly renewed by the motion of the glacier. It will be readily seen that such streams, by the peculiarities of their situation and action must exercise an influence in determining the precipitous character which the sides

of glacial valleys so often have. If it is objected that such water-worn surfaces are rarely met with upon the sides of valleys from which the glaciers have retreated, it must be remembered that the ice above the streams and the atmospheric agencies modify these surfaces after they have been left by the streams, hence the rocks have the features which they received from the last agent which acted upon them.

Still lower and quite underneath the side of the glacier there are larger and often much longer lateral streams, which are much more important agents in the excavation and formation of the valleys. These, flowing in channels of their own formation in the rock and quite below the ice, tend to deepen the valley along its edges and to give it that cañon-like form so often seen.

Sometimes the aqueous erosion under the sides of a glacier is greater than it is under the medial portion, and when this has been continued for long periods the edges of the valley have become the deepest portions, and when the lower end of the glacier has receded to this part of the valley it is often bifurcated, its terminations being upon opposite sides of the rocky eminence left in the central part of the valley. Such knolls or hills occur in the valleys of ancient glaciers, as, for example, in the valley of the Rhone at Sion, and they have always been a puzzle to the advocates of a purely glacial origin of such valleys. If, however, we duly recognize the power of sub-glacial streams, the hills which are sometimes left in positions where they have been fully exposed to the action of glaciers appear as a normal and not as an anomalous result of the agencies which have excavated such valleys.

With many other glaciers and often with other parts of the same glacier, the medial stream is the most important one in volume and power, and then it tends to make that part of the valley the deepest, and the glacier assumes a corresponding form.

In conclusion I will state that the observations of three summers among the glaciers of the Alps have led me to estimate the relative agency of glaciers and sub-glacial streams in the erosion of valleys as follows: viz., that the sub-glacial streams are of primary importance in working in advance of the ice in deepening and enlarging these valleys, and that the glaciers abrade, modify, and in a measure reduce the prominent portions left by the streams, and give them the well-known glaciated surfaces.

[I have not space in the narrow limits of this article to consider the valuable and exceedingly numerous contributions of others to the subject of glacial action.]

ART. XLVI.—*Notice of recent additions to the Marine Fauna of the eastern coast of North America, No. 2*; by A. E. VERRILL. *Brief contributions to Zoology from the Museum of Yale College.* No. XXXIX.

DURING the past summer Professor Baird established the headquarters of the U. S. Fish Commission at Gloucester, Mass. Numerous dredgings were made under the direction of the writer, in the U. S. Steamer Speedwell, commander Beardslee. Mr. Richard Rathbun, Mr. Sanderson Smith and others assisted in the invertebrate department, while Mr. G. Brown Goode, Mr. T. H. Bean and Mr. R. E. Earll, took charge of the Ichthyology. The temperatures were taken by Mr. Asaph Hall, Jr. Our dredgings extended over Massachusetts Bay and Stellwagen's Bank, and to the deeper waters of the Gulf of Maine, about forty-five miles east of Cape Ann. Although a very large and valuable collection, containing many additions to the fauna, was obtained by means of our dredges and trawls, more novelties, both among the fishes and invertebrates, were secured by inducing the fishermen engaged, in the fisheries of halibut and cod on the outer banks, to preserve and bring in the various things that become entangled in their trawl-lines. Many of the following species, some of them of great interest, were thus obtained by the fishermen, together with numerous specimens of many better known species, among which the most conspicuous and abundant are large and fine specimens of the corals, *Paragorgia arborea* and *Primnoa reseda*, while *Acanella Normani* has recently been brought in from many localities in considerable numbers.

ECHINODERMATA.

Pteraster pulvillus Sars. Norges Ecinod., p. 62, Pl. 6, figs. 14–16, Pl. 7, 8.

A well-developed specimen of this species was dredged in thirty-five fathoms, off the Isles of Shoals, N. H., by Dr. A. S. Packard, on the "Bache," in 1874. It may be distinguished from *P. militaris* by its more warty surface, more swollen form, with the rays narrower below and the transverse spines fewer, less prominent and less acute.

Porania grandis, sp. nov.

The greater radius of the larger one is 4·75 inches; radius of disk, 2·75. The greater radius of another is 4·35 inches; of disk, 2·70. The upper side, when fresh, was bright cherry-red; lower surface pale yellow. Easily distinguished by the nearly smooth, fleshy surface, without spines; but with two regular broad bands of soft slender papillæ along each ray on the upper side, and with radiating grooves on the lower side, which extend

also to the upper surface. Margin of disk without distinct spines, but with irregular rudimentary tubercles, covered by the skin. Adambulacral spines forming an inner row, two, united by a basal web, on each plate, and an outer series arranged in oblique transverse groups of about three; these are shorter and covered by the skin, which is everywhere finely granulose. No interbrachial spines, except one or two rudimentary ones, close to the mouth.

Two large and fine specimens of this species were taken on trawl-lines on the eastern slope of George's Bank, in about 220 fathoms, and presented by Capt. Anderson and the crew of the schooner Alice G. Wonson, August, 1878.

Asterina pygmæa, sp. nov.

A small species, perhaps young, with a rather flattened pentagonal disk, with edges concave, and very short obtuse rays. Upper surface covered with small, sub-acute, stoutish spines on the disk, mostly placed singly and not crowded; on the rays mostly in transverse groups of two or three on each plate. A short row of few conspicuous solitary pores for the papulæ are on each side of the base of the rays; margin of disk thin, fringed by a row of small slender spines borne on the ventral row of plates, which project more than the smaller dorsal ones; the latter bear a group of very small inconspicuous spines, and belong to the upper surface. Beneath, the disk is covered with soft skin, showing conspicuous radiating furrows between the relatively large, oblong, marginal plates, each of which bears a row of four to six small, slender, marginal spines on its outer end, but is elsewhere smooth, or, when dry, minutely granulose. There are eight of these plates on each interradial margin. The triangular interradial area has a few plates, some of which have one small acute spine. The ambulacral grooves are bordered by two rows of small, acute, rather stout spines on each side, those of the outer row usually standing erect, those of the inner ones often interlacing across the groove. Usually one inner and one outer spine to each plate, but close to the mouth, two inner ones sometimes on one plate. Smaller radius, $3·5^{mm}$; greater, 5^{mm}.

Cashe's Ledge, Gulf of Maine, fifty-two to ninety fathoms. Dredged by Dr. Packard and Mr. Cooke on the "Bache," in 1873.

Archaster Floræ, sp. nov.

Five rays; greater radii, 85 to 88^{mm}; smaller, 15 to 18^{mm}; breadth of arms at base, about 20^{mm}; in middle, about 12^{mm}; paxilligerous portion in middle, 7 to 9^{mm}, or about twice as wide as upper marginal plates. Disk moderately large, flat, with the central opening raised on a slight eminence. Arms elongated, flat above, regularly tapered to slender acute tips. Dorsal surface with the paxillæ evenly and regularly arranged, mostly with

about fourteen to eighteen small, short, round-tipped spinules at the summit; of these, ten to twelve are usually divergent and border the edge, and are a little longer and more slender than the four to six more rounded ones that form a central group. Marginal plates forty-five to forty-eight on each side; upper ones mostly higher than long, except toward the tips, even and regular, thickly covered with small spinules which are finer and more slender around the margins, where they are crowded and divergent, those over the central part being shorter, larger and more obtuse, with occasionally one or two, small, acute spines rising from the center of the plate, especially along the middle of the arm. Lower marginal plates opposite the upper and a little higher, covered with the same kinds of spinules, but mostly having a central, vertical row of two to four, slender, acute, spines, which are more or less appressed and scarcely longer than the plates, but longer than those on the upper plates. Adambulacral plates each with an inner fan-shaped group of eight or nine, slender, rather long spines, the central, longest, and with an outer, more or less circular, loose, divergent cluster of eight to ten shorter, slender spines; a similar, but mostly smaller and more regular, cluster occupies each of the pavement-like plates that cover the triangular interbrachial area and extend out along the arms between the marginal and adambulacral plates, in about three rows toward the base, but gradually narrowing to one, farther out.

Oral plates prominent, forming narrow elliptical "jaws" surrounded by two close rows of short spines, those of the inner row slightly divergent with enlarged rough tips, in close contact; those of the outer row shorter, with the tips flattened and closely pressed against the inner ones, so as to support them externally.

Color, in life, light purplish red above, yellow beneath. Dredged by us in 1877, about thirty miles south from Halifax, N. S., in 100 fathoms, fine compact sandy mud, associated with *Archaster arcticus*, *Astrogonium granulare*, *Asterias stellionura*, *Hippasteria phrygiana*, *Antedon Eschrichtzii*, *Pennatula aculeata*, *Eudendrium rameum*, etc.

Ophiacantha sp. Related to *O. cosmica* (fide Lyman).

Distinguished by having the disk thickly covered with minute, three-pronged, slender spinules. Mouth-plates extending into interbrachial spaces. Eastern slope of George's Bank, 220 fathoms, (schooner "Alice G. Wonson.")

Astrophyton eucnemis Müll. and Troschel.

Several specimens of this species, not before known south of the Gulf of St. Lawrence, were found clinging to specimens of *Paragorgia arborea*, from the eastern slope of George's Bank, in about 220 fathoms, (schooner "Alice G. Wonson.")

Astrochele, gen. nov.

Disk covered with small scales, above and below. Radial ribs well-developed. Genital openings small, oblique, close to base of arms, at each end of a depression in edge of disk. Teeth and tooth-papillæ spiniform, mouth papillæ irregular, small or rudimentary, few or solitary. Arm-spines thorny and claw-like. Arms annulated, granulated, long, slender undivided.

Astrochele Lymani, sp. nov.

Disk strongly five-lobed, the interbrachial spaces, in the dried specimen, much incurved. Radial ribs extending to near the center, highest and rather angular at the outer end. Whole surface of disk, including ribs, closely covered with small, convex, rounded, warty scales, with a somewhat larger central scale, surrounded by a circle of similar ones near the inner ends of the ribs and a few others irregularly placed between the ribs. On the ribs some of the scales are conical. Under surface, except jaws, covered with small round scales or granules concealing the plates. Teeth slender, acute, rough, in a single row, except the under ones (or tooth-papillæ), which are in pairs, but of same shape. On the side of jaws, near the tip, there is a very small acute conical mouth papilla, and sometimes another, still smaller, near the middle; a similar one is seen lower down on the lateral face of some of the jaws. Arms granulated like the disk, the annular ridges bearing also a row of small, strongly curved, acute, claw-like hooks, which become larger and more prominent toward the tips of the arms, especially beneath. Toward the base of the arms there are on the prominent, side arm-plates, beneath, about three spines having thickened bases and narrowed, acute, thorny, claw-like, brown tips.

Diameter of disk, 7^{mm}; length of arms four or five times as much. Found clinging to *Acanella Normani*, from south-eastern slope of Le Have Bank, 200 fathoms, Capt. Wm. McDonald, (schooner N. H. Phillips).

HYDROZOA.

Blastothela, gen. nov.

Hydroid allied to *Myriothela* and *Acaulis*. Body elongated, sessile, attached at base by slender, simple, root-like processes; a circle of slender tentacles near the base; above these are many stout simple processes (blastostyles), which bear the small sexual zooids (gonophores) on their sides; upper portion of body elongated, covered with small capitate tentacles.

Acaulis differs in having no blastostyles, and in the mode of attachment: *Myriothela* in having branched blastostyles, but no basal tentacles.

Blastothela rosea, sp. nov.

Body elongated and rather slender in expansion, with the *upper* portion round and usually nearly cylindrical, obtuse,

covered everywhere with small crowded capitate tentacles, with short pedicels; tip obtuse; blastostyles numerous, clustered about the base, large, elongated, cylindrical, obtuse or tapered at the tip, the sides covered with many very small, short, obtuse or capitate papillæ (? undeveloped gonophores), and bearing, among them, the few rounded, more or less irregular gonophores. Basal tentacles slender, slightly capitate, not so long as the blastostyles, and not in a regular circle.

Color light rosy red; the tentacles and gonophores whitish. Length, 24^{mm}; diameter, 10^{mm}; length of tentaculiferous portion, 13^{mm}; its diameter, $3{\cdot}5^{mm}$.

Gloucester, Mass., outer harbor, attached to *Ptilota serrata*, in seven fathoms, sandy bottom. A specimen, apparently the young of this species, was taken by us at Eastport, Me., in 1872, in about twenty fathoms.

Dicoryne flexuosa G. O. Sars.

Numerous specimens of this interesting hydroid were dredged both this year and last, in many localities, in the Gulf of Maine and off Nova Scotia, in 50 to 125 fathoms. It grows usually upon the shells of living *Neptunea Stimpsoni* and *N. decemcostata*, sometimes also on shells inhabited by *Eupaguri*. Often associated with *Eudendrium rameum*.

ANTHOZOA.

Pennatula borealis Sars.

Pennatula grandis Ehrenberg (non Pallas).

A fine large specimen of this species, taken on a trawl-line, between Sable I. Bank and Banquereau, N. S., in about 250 fathoms, was presented by Capt. J. W. Collins, of the schooner "Marion." It was previously known only from northern Scandinavia. Its height, preserved in alcohol, is 20·5 inches; length of peduncle to first alæ, 5·75; diameter of peduncle, in middle, ·5; of swollen portion, 1·10; of rachis, ·70; breadth across largest alæ, 5; length of largest alæ, 2·25; breadth, ·75; length along dorsal edge, 1·90; distance between alæ, ·30 to ·50.

Alæ 36 on one side, long, subtriangular, with the polyps in groups on the dorsal edge, forming two to four rows; polyp-cells large and prominent, with eight sharp, spiculose, projecting points. Middle of ventral surface naked, smooth, bordered on each side with a band of rudimentary zoöids. Color, bright dark red, polyps paler.

Balticina Finmarchica Gray.

Virgularia Finmarchica Sars, 1850.
Pavonaria Finmarchica Kölliker, Pennatuliden, p. 243.

A specimen of this rare species, not before known from America, was taken with the preceding and presented by Capt. Collins. The upper portion had been broken off, leaving the axis exposed for two inches, and to this two specimens of

Urticina nodosa were attached, their basal margins having, in each case, united around the axis, which is small and round.

The uninjured portion is 12·5 inches long; breadth across largest alæ, ·60; peduncle, to alæ, 4·50; to first zoöids, 3·20; breadth of largest alæ, ·50; height, without polyps, ·33; length of their acute marginal lobes, ·10; diameter of peduncle, ·30; of rachis, ·20.

Anthomastus, gen. nov.

Alcyonarian forming a large rounded polypiferous mass, raised on a short, stout, barren peduncle. Polyps few, very large, spiculose, entirely retractile into 8-rayed cells. Rudimentary zoöids numerous, minute, scattered between the polyps. Cœnenchyma abundant, firm, finely spiculose.

Anthomastus grandiflorus, sp. nov.

Corallum broadly capitate, surface finely granulose; polyp-cells not prominent. Peduncle, 50^{mm} broad, 30 high; polypiferous summit, 82 broad, 30 thick; expanded polyps, 36 long; 8 in diameter; 25–28^{mm} (1–1$\frac{1}{8}$ inch) across tentacles. Spicula of surface minute, rough stellate and capitate; beneath the surface are long slender spicula, and slender fusiform ones are abundant in the tentacles and pinnæ. Color, deep cherry-red. Off Sable Island, N. S., in about 250 fathoms, schooner Marion (coll. Newcomb). Two specimens were obtained.

Acanthogorgia armata, sp. nov.

Corallum slender, flexible, much and irregularly branched, somewhat in a plane, the branches occasionally uniting. Cœnenchyma thin, filled with conspicuous, white, rough, curved, fusiform spicula. Polyp-cells very much elongated, the length six to eight times the diameter, often curved, clavate, or capitate, smallest at base and suddenly enlarged near the summit, which is surmounted by eight groups of long, divergent, sharp spicula; sides of polyp-cells with eight low ridges, covered with elongated spicula, having an irregular chevroned arrangement. Height, about 8 inches; breadth, 6; length of cells, 5^{mm} to 8^{mm}; their diameter at base, ·8 to 1^{mm}; at summit, 1 to 1·5^{mm}. Color, ash-gray; axis, yellowish-brown.

Off Nova Scotia, 300 fathoms, Capt. T. Goodwin (sch. Elisha Crowell). A second specimen from off George's Bank, in about 220 fathoms, Capt. Anderson (schooner Alice G. Wonson).

Keratoisis ornata Verrill.

Of this species, described in the last number of this Journal, another specimen, taken with the two preceding, has been received from Mr. Geo. K. Allen, of the schooner "Marion." This has the cœnenchyma and polyps upon it, and is considerably taller, but the joints lack the golden color, and are plain brown. The polyp-cells are pale salmon, prominent, elongated,

expanding toward the end, and are crowded equally over the whole surface; they are covered with large, conspicuous, acute spicula, which are grouped at summit into eight sharp projecting points. The cœnenchyma is thin, translucent, yellowish, filled with long, slender, fusiform, acute spicula.

Height (base absent), 40 inches; diameter of trunk, without cells, ·28; length of cells, ·20; diameter, ·08; calcareous joints of stem, 2 to 2·5; flexible ones, ·15 to ·18. One branch is 27 inches long, without dividing. With this, five additional specimens of *Acanella Normani* were taken.

Flabellum Goodei, sp. nov.

A fine large species with a long, deep, compressed calicle, its longer diameter being nearly three times as great as the shorter. In a side view the summit is broadly rounded and the lateral edges form an angle of about 144°; they are formed by prominent acute costæ, while the principal lateral costæ are large, elevated, obtuse and irregularly roughened by numerous, obliquely ascending, raised lines, arranged in chevrons. There are eleven principal costæ on each side, making twenty-four in all, each of which corresponds to one large and two small septa; a small ridge, corresponding to the latter, is often seen on either side of the large costal ridges; alternating with the latter there are similar, but much smaller, secondary costæ. All the costæ become fainter toward the base, which terminates in a tapering subacute pedicle. Wall very thin, with a glossy epithecal coating; the edge recedes greatly between the principal septo-costal summits, which are very prominent. Septa about 96, very irregular, thin, with wide interspaces, the average distance between the twenty-four principal septa being about 10^{mm}; between the smaller ones, about 3^{mm}; inner side of the septa nearly straight, thin, smooth, the upper end mostly broadly rounded, often subtruncate at tip, scarcely projecting above the costal wall, and not recurved. Septa of the third and fourth cycles successively much narrower, those of the third with the summits much less elevated, while those of the last cycle rise nearly as high as the primaries, but are very much narrowed. Lateral surfaces of septa are smooth, but show lines of growth.

Height, 53^{mm}; along lateral edges, 42; length of calicle, 70; breadth, 26; space between inner edges of large septa, 5 to 8^{mm}. Color, light yellowish brown when fresh.

One living specimen from the eastern slope of George's Bank, in about 220 fathoms (schooner Alice G. Wonson).

Lophohelia prolifera Edw. and Haime.

A fragment of a large, dead, but nearly fresh, specimen of this coral, taken about thirty-nine miles S.S.W. from the N.W.

Light of Sable Island, in 160 fathoms, was presented by Dennis Thelneny (schooner Wm. Thompson.)

MOLLUSCA.

Sepiola leucoptera, sp. nov.

Species probably small, but the three specimens observed are probably not full grown. Body short, depressed, with the mantle smooth. Ventral surface, in middle, with a somewhat flattened heart-shaped or shield-shaped area, surrounded, except in front, by a silvery white band, having a pearly or opalescent luster. Eyes small, with round pupils. Fins large, in the living specimens nearly as long as body, broadly rounded; the posterior lobe reaches nearly to end of body, the anterior edge beyond front of mantle, to the eye. The anterior edge of the mantle is emarginate beneath; above it is broadly attached to the head. Sessile arms short; upper ones shortest; third pair largest; tentacular arms slender, extending back to end of body. Upper surface of body opalescent in some lights, thickly spotted with orange-brown, spots most numerous in middle line and extending to upper surface of head, and some also on outer surfaces of arms; anterior part of head white; fins, arms and extremity of body, translucent bluish white; upper surface of eyes opalescent, with silvery blue and red tints; head, below the eyes, silvery white; above eyes, blue. Length to base of arms, 14^{mm}, in alcohol; of mantle above, 8^{mm}; breadth, 7^{mm}; breadth across fins, 16^{mm}.

Gulf of Maine, 30 miles E. from Cape Ann, 110 fathoms, muddy bottom, associated with *Rossia sublævis* and *Octopus Bairdii*, Aug., 1878.

Chiton (*Acanthopleura*) *Hanleyi* (Bean).

A well-characterized living example of this species, new to America, was recently detected by Mr. Sanderson Smith, of our party, while dredging 8½ miles S. by E. ½ E. from Cape Ann, in thirty-eight fathoms, sand and gravel.

Pecten vitreus (Chemnitz).

This elegant little species, not before known from America, has been found in considerable numbers attached to *Paragorgia arborea* and *Acanella Normani*, from 220 fathoms, on the eastern slope of George's Bank (from the "Alice G. Wonson"), and on *Acanella*, from Banquereau, 150 fathoms, from Capt. Morrisey (schooner "Alice M. Williams").

Easily distinguished by its delicate, white, translucent shell; covered on both valves with very fine radiating striæ, and with delicate concentric lamellæ, which rise into numerous, minute, delicate, vaulted scales. The largest specimens are about ·5 of an inch in diameter.

ART. XLVII.—*Discovery of two more new Planets;* by C. H. F. PETERS. (From a letter to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., October 5, 1878.

TWO more planetoids have been discovered here, one on September 22d, and the other on September 30th. In order to avoid confusion, as the numbers perhaps may yet suffer some change, I have given immediately names to them, calling the former *Ismene*, the latter *Kolga*. The planet discovered on September 9, I have named *Phthia*.

The following observations have been obtained:

[191] *Ismene;* 11·5 magnitude:

1878.	Ham. Coll. m. t.	App. α.	App. δ.	
	h. m. s.	h. m. s.		
Sept. 22,	16 — —	1 10 8	+4° 56′ —″	(approx.)
27,	16 19 21	1 7 16·96	+4 32 7·2	12 ring micr. comp.
30,	13 21 51	1 5 37·53	+4 17 57·4	10 fil. micr. "
Oct. 2,	13 15 18	1 4 27·04	+4 8 18·5	10 " " "

[192] *Kolga;* 10·5 magnitude:

	h. m. s.	h. m. s.		
Sept. 30,	14 2 46	23 45 4·56	−8° 8′ 35·3″	10 fil. micr. comp.
Oct. 1,	10 20 20	23 44 33·66	−8 15 15·8	12 ring " "
2,	12 28 49	23 43 50·44	−8 23 36·8	10 filar " "
4,	13 10 48	23 42 35·61	−8 38 57·4	12 ring " "

The strong motion of the last planet in declination discards the idea of its being identical with [162] *Laurentia*, which was observed only in one appearance, and has not been found, neither in the preceding nor in the present opposition. The numbers attributed to the last two planets therefore are upon the assumption, that the planet found by Professor Watson on Sept. 22d also is not identical with [162].

ART. XLVIII.—*The Sonorous Voltameter;** by THOMAS A. EDISON, Ph.D.

THE sonorous or bubble voltameter consists of an electrolytic cell with two electrodes, one in free contact with a standard decomposable solution and the other completely insulated by vulcanized rubber except two small apertures, one of which gives the solution free access to the insulated electrode, and the other allows the escape of bubbles of hydrogen as they are evolved by electrolysis. With a given current and a given resistance a bubble is obtained each second, which is seen at the moment of rising and which at the same time gives a sound when it reaches the air. The resistance may be reduced so as to give

* Read at the St. Louis meeting of the American Association.

one bubble in one, five, ten or fifty seconds, or in as many hours. I have compared this instrument with the ordinary voltameter and find it much more accurate. By the use of a very small insulated electrode and but one aperture, through which both the gas and water current must pass, great increase of resistance takes place at the moment when the bubble is forming; and just before it rises, a sounder magnet included within the battery circuit opens, closing again when the bubble escapes, thus allowing by means of a Morse register the time of each bubble to be recorded automatically. This apparatus, when properly made, will be found very reliable and useful in some kinds of work, such as measuring the electro-motive force of batteries, etc. By shunting the voltameter, and using a recorder, it becomes a measurer not only of the current passing at the time, but also of that which has passed through a circuit from any source during a given interval.

Menlo Park, N. J., July 13, 1878.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. ***On the Behavior of Hydrogen peroxide with the Alkalies.***—In his second paper on hydrogen peroxide, Schöne discusses the relations of this substance to the alkalies, with particular reference to the decomposing action of these upon the peroxide; an action classed as "catalytic" by Berzelius. His first efforts were directed to the production of peroxide hydrates of the alkalies analogous to those of the alkaline earths. For this purpose a solution of hydorgen peroxide containing three or four per cent, was mixed with a ten per cent sodium hydrate solution in equivalent proportions. A rise of 4° to 5° C. took place, with a very slight evolution of gas. On concentrating the solution in a vacuum, efflorescent crystals separated on the edges at first, and then large tabular crystals formed in the solution. If instead of evaporating the solution, once and a half or twice its volume of absolute alcohol be added, and it be allowed to stand in a cool place for twenty-four hours, spear-shaped crystals often several centimeters long, appear in the solution. On analysis they give numbers agreeing with the formula $Na_2O_2.(H_2O)_8$. They are identical with those obtained later by Fairley* in the same manner, and with those obtained by Vernon Harcourt† by solution of sodium dioxide in water. When rapidly heated in a glass tube the crystals melt, froth, evolve oxygen and leave sodium hydrate. In closed vessels, the same decomposition takes place more slowly, requiring three months for completion. Absolute alcohol preserves it pretty well, if carbon dioxide be excluded. On examining the efflorescence above

* J. Chem. Soc., xxxi, 1, 125, 1877. † Id., xiv, 274, 1862.

mentioned, it was found to be a mixture of the substance already described and of another substance having the formula $Na_2H_4O_6$, or $Na_2O_2(H_2O_2)_2$, a compound of sodium peroxide with hydrogen peroxide. To prepare it, a mixture of one molecule of sodium hydrate and about three and a half molecules of hydrogen peroxide solution are mixed and evaporated in vacuo. The crystals are colorless and very minute; are at first transparent, very soluble in water, dissolve in this and in dilute acids without evolution of gas, and effloresce in dry air. In vacuo over sulphuric acid they lose four molecules of water, leaving $Na_2H_4O_6$. A similar peroxide hydrate was obtained with potassium, though mixing the solutions and evaporating gave only a yellow amorphous mixture of potassium tetroxide and potassium hydrate, $K_2O_4+(KOH+H_2O)_4$. But if excess of hydrogen peroxide be used, and the evaporation be conducted at a low temperature $-10°$ C., a white opaque mass results which is very hygroscopic and has the formula $K_2H_4O_6$, or $K_2O_2(H_2O_2)_2$. These facts the author uses to explain the "catalytic" action, as follows: The decomposition of hydrogen peroxide in alkaline solutions is due: 1st, to the tendency of the alkalies to form compounds of the composition $R_2H_4O_6$ or $R_2O_2.(H_2O_2)_2$; 2d, to the tendency of the alkali metal within this compound to oxidize itself to a higher oxide, the tetroxide; and 3d, to the reduction of the tetroxide to dioxide by the water present.—*Liebig's Annalen*, cxciii, 241, August, 1878.

G. F. B.

2. *On a Series of Magnetic Compounds having the Formula* $R''Fe_2O_4$.—Of the possible compounds of ferric oxide with the basic oxides isomorphous with ferrous oxide, only two, $MgFe_2O_4$, prepared by Deville, and $ZnFe_2O_4$, by Ebelman, both produced at high temperatures, are known. LIST has undertaken to prepare these compounds in the wet way. A ferric chloride solution as nearly neutral as possible, was precipitated with excess of lime water or of calcium saccharate, the bright leather-brown precipitate washed with lime water, filtered, dried and ignited. A dark brown friable powder, having the composition $CaFe_2O_4$, was obtained, which was strongly attracted by the magnet. Barium-ferric oxide, obtained similarly, had similar properties. The magnesium compound, prepared either by adding magnesia to a neutral solution of ferric chloride or by adding potassium or sodium hydrate to mixed solutions of ferric chloride and magnesium sulphate, is a cinnamon-brown powder, strongly magnetic. Manganous, zinc, nickelous, cuprous and lead oxides yielded like magnetic compounds. Even potassium and sodium oxides, ignited with ferric oxide, yield a compound attracted by the magnet.—*Ber. Berl. Chem. Ges.*, xi, 1512, Sept., 1878. G. F. B.

3. *On the Copper-zinc couple and on Nascent Hydrogen.*—In view of the fact that finely divided copper charged with hydrogen converts niter into nitrite and ammonia and reduces potassium chlorate to chloride, GLADSTONE and TRIBE have been led to study the reducing action of palladium and platinum-hydrogen and to

compare it with that of the copper-zinc couple. They also tried copper-hydrogen and carbon-hydrogen. They find a close analogy between some actions of the copper-zinc couple, of occluded hydrogen and of the so-called nascent hydrogen, and conclude that the great power of hydrogenization and reduction of the copper-zinc couple depends on the absorption of hydrogen by the finely divided metal. The activity of the hydrogen in these cases may be explained by supposing (1) that its energy is increased by a more negative element, or (2) that the atomic condition of occluded hydrogen differs from that of ordinary hydrogen, or (3) that the increased power of the hydrogen is due to its condensed condition. Since in those changes effected by nascent hydrogen, the gas is set free in contact with a metal which condenses it, the authors incline to the opinion that the activity of nascent hydrogen is due only to its occluded condition.—*J. Chem. Soc.*, xxxiii, 306, Aug., 1878. G. F. B.

4. *On the Action of Nitrous acid on Unsaturated Hydrocarbons.*—Tönnies has observed that when a concentrated solution of potassium nitrite is mixed with a solution of an unsaturated hydrocarbon in glacial acetic acid, products are obtained which analysis shows to be direct addition products of the hydrocarbon and N_2O_3. Thus furfurbutylene gives a beautifully crystallized compound $C_8H_{10}O.N_2O_3$, phenylbutylene gives $C_{10}H_{12}.N_2O_3$, and styrol, totylbutylene, anethol and amylene give similar bodies. On reduction, these bodies give bases which contain in the place of the N_2O_3 group, an amido and an hydroxyl group. Thus the furfurbutylene compound affords a well crystallized hydrochlorate $C_8H_{10}O.OH.NH_2.HCl$, and the phenylbutylene compound gives $C_{10}H_{12}.OH.NH_2.HCl$. Hence the nitrous oxide, N_2O_3, splits into NO and ONO, so that the compound may be considered a nitroso-substitution product, on the one side, and a nitrous ether on the other. With this view the results of reduction agree, the nitroso-substitution product being always converted into an amido-compound, and the nitrous ether into an alcohol.—*Ber. Berl. Chem. Ges.*, xi, 1511, September, 1878. G. F. B.

5. *On the Production of Methyl Aldehyde.*—The method originally described by Hofmann for preparing methyl aldehyde consisted in passing the vapor of methyl alcohol mixed with air over an ignited platinum spiral. Later Volhard, producing the aldehyde by condensing the vapors from an aphlogistic lamp fed with methyl alcohol, showed that the condensed liquid contained only one per cent. Hofmann has now devised an improved method of preparation which consists in passing a suitable mixture of methyl alcohol vapor and air through a platinum tube containing a bundle of platinum wires, moderately heated. Abundance of methyl aldehyde is formed and on condensing the vapors a liquid is obtained which contains not less than five per cent of this substance. Since the process is continuous, large quantities may thus be prepared. By removing the alcohol by distillation and the water by freezing the liquid may be concentrated so as to contain ten per

cent of methyl aldehyde.—*Ber. Berl. Chem. Ges.*, xi, 1685, September, 1878. G. F. B.

6. *On the Determination of Phenol volumetrically.*—DEGENER has proposed a method for the volumetric estimation of phenol based upon the fact that bromine in aqueous solution acts upon phenol dissolved in water producing tribromphenol and hydrogen bromide: $C_6H_5OH + (Br_2)_3 = C_6H_2Br_3OH + (HBr)_3$. On adding the bromine water, the solution at first is clear; but soon it becomes turbid and finally on continued agitation, a snow-white voluminous curdy precipitate, consisting of fine interlacing needles, is thrown down, leaving the liquid clear. The slightest excess of bromine is recognized by potassium iodide and starch paper. To estimate an amount of phenol, up to five per cent, it is sufficient to add one drop of a bromine solution in excess containing forty grams bromine and half as much potassium bromide in a liter, provided the titered fluid does not exceed forty to fifty cubic centimeters. The titer of this bromine water, which varies from day to day, is fixed by adding a known quantity to a solution of potassium iodide, and titering the iodine set free with sodium hyposulphite. A series of experiments with phenol showed the process to be accurate to 0·12 per cent.—*J. prakt. Ch.*, II, xvii, 390, July, 1878. G. F. B.

7. *Vanillin in Gum Benzoin from Siam.*—JANNASCH and RUMP have succeeded in preparing vanillin from the gum benzoin of Siam, in which gum it was first discovered by the latter chemist. The finely divided gum is intimately mixed with half its weight of calcium hydrate in an iron vessel, water being added to make a stiff paste. Ten or twelve times the quantity of boiling water is added with continued stirring, the solution is freed from benzoic acid by acidifying it, and the acid filtrate is extracted with ether. On evaporation of the ether, impure vanillin is left. After recrystallization from water, it is soluble in ether, alcohol, chloroform, glacial acetic acid, less so in cold benzene, crystallizing from all in prismatic crystals. It fuses at 81°, reddens litmus when in solution, expels carbon dioxide from carbonates forming salts, gives a dirty green or violet color with ferric chloride, has the taste and odor of vanilla and precipitates lead acetate and silver nitrate. Purified by hydrosodium sulphite its analysis gave numbers agreeing with those of vanillin. Petroleum ether, boiling point below 90°, dissolves it abundantly when hot, scarcely at all when cold. It crystallizes from this solvent on cooling in splendid groups of long highly refracting prisms of considerable size.—*Ber. Berl. Chem. Ges.*, xi, 1634, September, 1878. G. F. B.

8. *On the Alkaloids of the Aconites.*—WRIGHT and LUFF, in their third and concluding paper on the alkaloids of the aconites, discuss, (1) the action of saponifying agents on aconitine, (2) the action of acids on aconitine, (3) the action of organic anhydrides on aconitine, aconine and pseudaconine, (4) the decomposition products of picraconitine, and (5) the alkaloid constituents of aconite roots generally. As a result of their investigations they

conclude: 1st, that *Aconitum ferox* roots contain a characteristic crystallizable and highly active alkaloid, pseudaconitine $C_{36}H_{49}NO_{12}$, the aurochloride and nitrate crystallizing. 2d, *A. napellus* roots contain chiefly aconitine, $C_{33}H_{43}NO_{12}$, crystallizable, fusing at 184°, and forming crystallizable salts. 3d, Pseudaconitine and aconitine readily lose water, forming apo-derivatives closely resembling the original bases. 4th, Saponifying agents break up pseudaconitine, aconitine and picraconitine, forming benzoic acid or a derivative of it, and new bases, pseudaconine $C_{27}H_{41}NO_8$ aconine $C_{26}H_{39}NO_{11}$, and picraconine $C_{24}H_{41}NO_9$. 5th, On treatment with organic acids or anhydrides, aconitine and pseudaconitine lose the elements of water and form derivatives in which H is replaced by an acid radical. 6th, Aconine and pseudaconine form analogous derivatives by the action of organic anhydrides and perhaps also of organic acids. 7th, Certain acids, however, only transform aconine and pseudaconine into apo-derivatives. 8th, Since there is no particular difficulty in obtaining well crystallized salts and bases both from *A. ferox* and *A. napellus*, the use of the amorphous precipitated substances at present sold as aconitine should be discontinued and that of the crystallized alkaloids and their salts substituted.—*J. Chem. Soc.*, xxxiii, 318, Aug., 1878. G. F. B.

9. *On a supposed new element Mosandrum.*—Dr. J. Lawrence Smith, in a recent article in the Comptes Rendus (July 22, 1878) has announced the discovery of a new earth in the samarskite of North Carolina. This earth belongs to the cerium group and to it the name Mosandra, or Mosandrum oxide has been given. M. Marignac, to whom some of the material had been submitted, has suggested (C. R., Aug., 1878) that the supposed new earth is probably identical with *terbia*. Dr. Smith, while admitting the presence of the terbia in the mineral still claims that a distinct earth—the mosandra—is also present; he has the subject still under examination.

10. *Specific Heat of Glucinum.*—The specific heat of this elementary substance has been very carefully determined by Nilson and Petterson, and the results of their investigation are given in the Ann. de Chim. et Phys. for July. These chemists prepared glucinum by heating to a red heat in a massive iron cylinder—hermetically closed by a screw-cap—a mixture of chloride of glucinum and metallic sodium. The product was a mixture of common salt and glucinum, which when washed with water left the metal in brilliant spangles, dendrites or globules. The metal thus prepared is described as of the gray color of steel or tin, as very hard, and having a great tendency to crystallize. The globules readily break under the hammer, and the metal does not melt at a temperature at which common salt rapidly volatilizes. It undergoes no change in the air even when heated to a high temperature, and in a current of oxygen gas it remains unaltered at a red heat. The vapor of sulphur is without action upon it, but in the oxidizing flame of a blowpipe the metal becomes covered with a coating of oxide, but without any appearance of igni-

tion. Glucinum does not act on pure water, either at the ordinary temperature or when heated. It decomposes, however, the hydrates of potassium and sodium as well as hydrochloric and sulphuric acids, determining a brisk evolution of hydrogen when the materials are heated. Nitric acid attacks the metal more slowly. When heated in a current of dry chlorine, the metal burns with great brilliancy, yielding white crystals of its chloride besides a small red sublimate of ferric chloride and a residue of undecomposed glucina. This reaction indicates the nature of the impurities, and analysis showed that the crude metal contained

Silica	0·99
Iron	2·08
Glucina	9·99
Glucinum	86·94
	100·

An accurate knowledge of the nature and amount of the impurities enabled the experimenters to deduce from the observed specific gravity of the crude metal 1·9101 the specific gravity of pure glucinum, which they fix at 1·64. In like manner the specific heat of pure glucinum was deduced from that of the crude metal determined with Bunsen's ice calorimeter, after the method of Schüller and Wartha. The result calculated from the mean of four observations gives for the specific heat of glucinum 0·4084. This result is very interesting, as it indicates a closer relation between glucinum and aluminum than has usually been supposed to exist. The specific heat of aluminum multiplied by its atomic weight gives the product $0·2143 \times 27·5 = 5·89$, and if we assume that glucina, like alumina, is a sesquioxide, then the atomic weight of glucinum would be 13·95 and $0·4084 \times 13·9 = 5·70$; while, on the other hand, if glucina is a protoxide, the atomic weight of the element would be 9·3, which when multiplied by the specific heat just found, would give a product wholly irreconcilable with the usual theory. The same conclusion in regard to the constitution of glucina was reached by the writer several years since, on finding that in the mineral Danalite alumina might replace glucina. It is also worthy of notice that if this view of the constitution of the oxide is correct, the atomic weight of glucinum is one half that of aluminum, within the limit of uncertainty which still attaches to these values. J. P. C., JR.

11. *Photometric Measurements of Electric Lights.*—Mr. W. Abney uses for this purpose the two shadows of a metal rod which is 1 cm. in diameter, 7·5 cm. long. The shadows are 7·2 cm. distant from one another and are thrown upon a screen. By means of a heliometric adjustment and a divided lens the two images of the shadows (seen through oiled paper) are made to approach each other and are observed through an eye-piece. The lights are made equal by the approach or recession of one. With the use of homogeneous lights the measurements are very exact; for instance, in the comparison of a candle and a lamp the ratio varies from 1 : 10·18 to 1 : 10·26. By means of red glass and an

ammoniacal solution of copper the light of a self-regulating electric lamp, provided with carbons of one-half inch square section and run at different speeds by means of a gram machine, was compared, under varied circumstances of work and resistance of circuit, with a parafine lamp. Reflected light was carefully shut off and the light passed through a square opening of eighteen inches in a wall of the laboratory. The actinic effects were also compared according to the method of Roscoe. It was found that the brightness, or intensity, as well as the actinic effect, increased in a greater ratio than the number of revolutions of the generator and the horse power consumed. The increase was slower for the red rays, quicker for the blue and quickest for the actinic effect. The following table exhibits this result:

No. of revolutions.	Horse power.	Blue light.	Red light.	Actinic effect.
240	1·6	360 candles.	180 candles.	----
350	2·5	750 "	----	890 candles.
460	5·6	2500 "	860 "	2750 "
540	--	6500 "	1620 "	----
565	9·0	----	2100 "	11020 "
580	--	----	----	----

The resistance of the voltaic arc was about 0·18 of an ohm with 375 to 383 revolutions per minute; the electromotive power of the machine was 111 volts. The resistance of the circuit was about 0·5 of an ohm.—*Proc. Roy. Soc.*, xxvii, 157–166, 1878; *Beiblätter Physik und Chemie*, ii, 497. J. T.

12. *A new Electric Lamp.*—M. G. Reynier describes in the Comptes Rendus, 1878, lxxxvi, p. 1193–94, a light which obviates the use of regulators. It consists simply of a thin rod of carbon which is connected with one pole of the electric generator and is pressed against a wheel which is connected with the other pole. The carbon glows at the point of contact and as it burns away moves the wheel to another point of contact. The inventor claims to have produced a light by means of four Bunsen elements and to have produced several lights in the same circuit. J. T.

13. *The strength of the Electric Telephonic Currents.*—Bosscha has made a determination of the relative comparative strength of currents which are generated by the voice in telephones. Upon the middle of the plate of a horizontal telephone a stiff bristle was attached and the excursions of this were observed through a microscope which permitted of a movement of a thousandth of a millimeter (mikron μ). Movements of 5·77 to 7·77 mikron indicated in one telephone (numbered 3) currents of 0·1627 and 0·2337 Weber's unit, showing that the currents were nearly proportional to the movements. The unit of current gave a movement $\varepsilon = 34{\cdot}3\mu$. With three other telephones numbered 1, 2 and 4, ε had the values $\varepsilon = 22{\cdot}5\mu$, $\varepsilon = 8{\cdot}7\mu$ and $35{\cdot}9\mu$. In order to ascertain the limit of currents which produced audible tones in the telephone, the instrument was placed in a circuit with a Daniell cell and

the resistances were varied. In all four telephones, tones were heard when the strength of the current and the values of ε were as follows:

	1	2	3	4
S	0·000100	0·000153	0·000084	0·000066
ε	0·00225μ	0·00133	0·00288	0·00237

With a movement equivalent to $\frac{1}{260}$ of the wave-length of sodium the telephone was heard. This explains the fact that Professor Bell heard sounds when the space between the vibrating membrane and the magnet was filled with a cork. Bosscha thus shows that Professor Bell's hypothesis that the movement of the plate was molecular is unnecessary. The currents which were necessary to produce the measured excursions of the style observed by the microscope were measured by Weber's multiplication method. A tone of 440 vibrations producing an amplitude of 1 mikron indicated a current of 0·0000792 and produced an audible sound in the telephone. Bosscha speaks of the great sensitiveness of the telephone, and remarks that it can be used in observations upon the stratification noticed in Geissler tubes.—*Beiblätter Physik und Chemie*, ii, 513. J. T.

14. *On the hypothesis of a change of climate through changes in the obliquity of the ecliptic, or changes in the position of the axis of rotation.* The following remarks on this subject are cited from a paper by Dr. JAMES CROLL, entitled Cataclysmic theories of Geological Climate, which has appeared in the September number of the Geological Magazine (London).—The theory of a change in the obliquity of the ecliptic has been appealed to, in order to account for changes in geological climate. This theory for a time met with a favorable reception; but, as might have been expected, it was soon abandoned. The researches of Mr. Stockwell of America, and of Mr. George Darwin and others in this country, have put it beyond doubt that no probable amount of geographical revolution could ever have altered the obliquity to any sensible extent beyond its present narrow limits. It has been demonstrated, for example, by Mr. George Darwin, that supposing the whole equatorial regions up to latitude 45° north and south were sea, and the water to the depth of 2,000 feet were placed on the Polar regions in the form of ice—and this is the most favorable re-distribution of weight possible for producing a change of obliquity—it would not shift the Arctic circle by so much as half an inch!

Variations in the obliquity of the ecliptic having been given up as hopeless, geologists and physicists are now inquiring whether the true cause may not be found in a change in the position of the earth's axis of rotation. Fortunately this question has been taken up by several able mathematicians, among whom are Sir William Thomson,* Professor Haughton,† Mr. George Darwin,‡ the Rev. I. F. Twisden§ and others, and the result arrived at

* British Association Report, 1876, part II, p. 11.
† Proceedings of Royal Society, vol. xxvi. p. 51.
‡ Transactions of Royal Society, vol. clxvii, part I.
§ Quarterly Jour. of Geological Society, Feb., 1878.

ought to convince every geologist how hopeless it is to expect aid in this direction.

Mr. George Darwin has demonstrated that in order to displace the pole merely 1° 46′ from its present position, one-twentieth of the entire surface of the globe would require to be elevated to a height of 10,000 feet, with a corresponding subsidence in another quadrant. There probably never was an upheaval of such magnitude in the history of our earth. And to produce a deflection of 3° 17′ (a deflection which would hardly sensibly affect climate), no less than one-tenth of the entire surface would require to be elevated to that height. A continent ten times the size of Europe elevated two miles would do little more than bring London to the latitude of Edinburgh, or Edinburgh to the latitude of London. He must be a sanguine geologist indeed who can expect to account for the glaciation of this country, or for the former absence of ice around the poles by this means. We know perfectly well that since the glacial epoch there have been no changes in the physical geography of the earth sufficient to deflect the pole half a dozen of miles, far less half a dozen of degrees. It does not help the matter much to assume a distortion of the whole solid mass of the globe. This, it is true, would give a few degrees additional deflection of the pole, but that such a distortion actually took place is more opposed to geology and physics than even the elevation of a continent ten times the size of Europe to a height of two miles.

Mr. Twisden, in his valuable memoir referred to, has shown even more convincingly how impossible it is to account for the great changes of geological climate on the hypothesis of a change in the axis of rotation. This conclusion has been further borne out by another mathematician, the Rev. E. Hill, in an article in the June number of the Geological Magazine. And Professor Haughton, in a paper read before the Royal Society, April 4th, and published in Nature, July 4th, entitled "A Geological Proof that the changes of climate in past times were not due to changes in the position of the Pole," has proved from geological evidence that the pole has never shifted its position to any great extent. "If we examine," he says, "the localities of the Arctic regions and consider carefully their relations to the position of the present North Pole, we find that we can demonstrate that the pole has not sensibly changed its place during geological periods, and that the hypothesis of a shifting pole (even if permitted by mechanical considerations) is inadmissible to account for changes in geological climates."

There is no geological evidence to show that since Silurian times the Atlantic and Pacific were ever in their broad features otherwise than they are now—two immense oceans separated by the Eastern and Western continents—and there is not the shadow of a reason to conclude that the poles have ever shifted much from their present position. On this point I cannot do better than quote the opinion recently expressed by Sir William Thomson.

"As to changes of the earth's axis, I need not repeat the statement of dynamical principles which I gave with experimental illustrations to the Society three years ago; but may remind you of the chief result, which is that, for steady rotation, the axis round which the earth revolves must be a principal axis of inertia,' that is to say, such an axis that the centrifugal forces called into play by the rotation balance one another. The vast transpositions of matter at the earth's surface, or else distortions of the whole solid mass, which must have taken place to alter the axis sufficiently to produce sensible changes of the climate in any region must be considered and shown to be possible, or probable, before any hypothesis accounting for changes of climate by alterations of the axis can be admitted. This question has been exhaustively dealt with by Mr. George Darwin in a paper recently communicated to the Royal Society of London, and the requisitions of dynamical mathematics for an alteration of even so much as two or three degrees in the earth's axis in what may be practically called geological time, shown to be on purely geological grounds exceedingly improbable. But even suppose such a change as would bring ten or twenty degrees of more indulgent sky to the American Arctic Archipelago, it would bring Nova Zembla and Siberia by so much nearer to the pole: and it seems that there is probably as much need of accounting for a warm climate on one side as on the other side of the pole.* There is, in fact, no evidence in geological climate throughout those parts of the world which geological investigation has reached, to give any indication of the poles having been anywhere but where they are, at any period of geological time."

In the memoir from which the preceding paragraph is quoted, Sir William maintains that an increase in the amount of heat conveyed by ocean currents to the Arctic regions, combined with the effect of clouds, wind and aqueous vapor, is perfectly sufficient to account for the warm and temperate condition of climate which have prevailed during the Miocene and other periods.

Now this is the very point for which I have been contending for upward of a dozen of years. The only essential difference between Sir William's views and my own is simply this: he accounts for an increase in the flow of warm water to the Arctic regions by a submergence of the circumpolar land, whereas I attribute it to certain agencies brought into operation by an increase in the eccentricity of the earth's orbit.

15. *Cause of the cold of a Glacial era;* by JAMES CROLL, (Ibid).—When the eccentricity of the earth's orbit is at a high value and the northern winter solstice is in perihelion, agencies are brought into operation which make the southeast trade winds stronger than the northeast and compel them to blow over upon the northern hemisphere as far probably as the Tropic of Cancer. The result is that all the great equatorial waters of the ocean are

* This has been proved to be the case by Professor Haughton, in his paper to the Royal Society; "Nature," July 4, 1878.—J. C.

impelled into the northern hemisphere, which thus, in consequence of the immense accumulation of warm water, has its temperature raised, and snow and ice to a great extent must then disappear from the Arctic regions. When the precession of the equinoxes brings round the winter solstice to aphelion, the condition of things on the two hemispheres is reversed, and the northeast trades then blow over upon the southern hemispheres, carrying the great equatorial currents along with them. The warm water being thus wholly withdrawn from the northern hemisphere its temperature sinks enormously and snow and ice begin to accumulate in temperate regions. The amount of precipitation in the form of snow in temperate regions is at the same time enormously increased by the excess of evaporation in low latitudes resulting from the nearness of the sun in perihelion during summer.

The final result to which we are, therefore, led is, that those warm and cold periods which have alternately prevailed during past ages, are simply the great secular summers and winters of our globe, depending as truly as the annual ones do upon planetary motions, and like them also fulfilling some important ends in the economy of nature.

16. *Scientific Memoirs; being Experimental Contributions to a Knowledge of Radiant Energy.* By John William Draper, M.D., LL.D., President of the Faculty of Science in the University of New York, etc. Large 8vo, 473 pp. New York, 1878. (Harper & Brothers.)—The life of Dr. Draper has been an exceedingly busy one. For a period of more than forty years, in addition to his extended literary labors, he has devoted himself to experimental research with a rare success, and has in consequence been a prominent contributor to the development of many of the most important discoveries of modern science. Of the many scientific papers which he has published, he has collected together in the volume before us only those which relate to his investigations in radiant energy. This action is fully justified not only by the exceptional importance just now of this department of physics, but also because the American Academy of Arts and Sciences at Boston has recently individualized Dr. Draper's share in its evolution by awarding him the Rumford gold medal, and thus placing him on the illustrious roll of those who have made important discoveries relating to light or heat; a roll on which are the names of Hare, Ericsson, Treadwell, Alvan Clark, and Corliss. To particularize individual discoveries in a book, where there are so many and where all are so good, is by no means an easy task. Dr. Draper's investigations on the temperature of incandescence, and on the character of the light emitted at different temperatures (1847); on the photographic process, in the course of which he took the first photograph ever taken of the moon and of the human face as well as the first micro-photograph (1840); on the spectrum, both prismatic and diffraction, in which the distribution of energy was determined and the foundation laid for spectrum analysis (1857, 1872); on phosphorescence and the effect of heat on it

(1851); on the decomposition of carbonic acid by plants, in which the luminous rays were proved to be the active ones, and not the chemical rays (1843); on the chlor-hydrogen photometer, for measuring the intensity of the chemical radiations (1843); on the phenomena of capillarity, including their electrical aspect (1834–1845); and on thermo-electricity (1840); all these are researches of the highest order. In cases where the importance of the memoir seemed to require it, the publication of it has been in full. In other cases only in abstract; though the fullest references to the original paper are always given. Although we have in this volume a record of the investigations of but a single individual, and these only in a single direction; and although many of the original memoirs have been condensed, in some cases being barely mentioned, yet the results make a goodly volume of 473 pages. In thus collecting together the valuable work which he has accomplished, Dr. Draper has not only done an important service to American science, and produced a book of which it may be proud, but he has placed all students of radiant energy under obligation to him, since they now have these most important memoirs in a form convenient for constant reference and consultation. In his preface, the author hints that the still larger collection of memoirs on chemical, electrical and physiological topics, some of them as yet unpublished, may be the subject matter of a future volume. We sincerely hope that he may be induced before long, to undertake the work of preparing such a volume, and thus to leave on record in a permanent and complete form, the results of his extensive labors in science. The book is issued in handsome style, and has an excellent steel plate likeness of Dr. Draper as a frontispiece.

17. *Elements of Dynamic, an introduction to the study of Motion and Rest in solid and fluid bodies;* by W. K. CLIFFORD. Part I. Kinematic. 8vo, 221 pp. Macmillan & Co.—This book differs so much from the usual works on the same subject that it deserves special notice. A difference of minor importance is to be seen in the title, namely the dropping of the final *s* in the words Dynamics, Kinematics, Statics, &c. There is a free use with technical definitions of Saxon words, as *step*, *spin*, *twist*, *squirt*, *whirl*, &c. To the following extent quaternions are tacitly introduced. Vectors with their sums and fluxes are defined and used. The scalar and vector products of two vectors are treated as separate products, not as parts of a single one. The quotient of vectors is not used at all.

The following is the definition of *force* (p. 2). "It is found that the change of motion of any body depends partly on the position of distant bodies, and partly on the strain of contiguous bodies. Considered as so depending, the rate of change of motion is called *force*." That this definition does not fairly express the meaning of the word as good writers have heretofore properly used it may be seen by trying to put *rate of change of motion* for *force* in their sentences. For instance, Newton's first two laws of motion

assume a strange form with such treatment. It may be desirable, especially in pure Kinematics, to have a term to express that change of motion which *measures* force. But if so, is it not a fair demand that some new word be taken or coined for the purpose? The word force has been already used in too many different senses.

This book is called *Elements*, and it is really elementary, even though in some parts, owing to its terseness, it is not very easy reading. It is certainly the most suggestive book we know of on the subject. H. A. N.

18. *Sound: a series of simple, entertaining and inexpensive experiments in the Phenomena of Sound, for the use of students of every age;* by ALFRED M. MAYER, Professor of Physics in the Stevens Institute of Technology, etc. 179 pp., 12mo. New York, 1878. (D. Appleton & Co.)—This is number two of the "Experimental Science Series for Beginners," of which the first volume, upon Light, has already been noticed in this Journal. The object of the volume is to present the leading phenomena of sound in a simple and entertaining manner, by the use of such materials as are almost everywhere at hand, and with apparatus which any ingenious student can construct for himself. To present the elements of an abstruse subject in such a way as to make the exposition easily comprehensible by a mind not specially trained in it, and at the same time correct and satisfactory from a scientific point of view, is one of the most difficult undertakings in the work of an instructor. Add to this the task of bringing the experimental illustration of a science like that of acoustics, which requires such refinement in the apparatus and its manipulation, within the resources of everyone, and we have the difficulty very greatly increased. Professor Mayer's well-known experimental skill has enabled him to accomplish the work in an admirable manner, and he has laid under obligation to him not only the student and the amateur experimenter, but the teacher, who will derive many valuable suggestions as to his own work from this little volume. The subject is arranged in a very clear and methodical manner, and treated in a vivacious and entertaining style. The experiments, many of which are novel, unite extreme simplicity with elegance of conception and scientific precision, and cannot fail to interest and stimulate the minds of the students into whose hands the volume may fall. The illustrations, which are numerous, are excellently done, and give the book a very attractive appearance. A. W. W.

19. *A Contribution to the History of Spectrum Analysis;* by G. F. BECKER. (Communicated.)—In all the historical notices which have appeared on the subject of Spectrum Analysis, there exists, so far as I am aware, absolutely no mention of an investigation which must be regarded as an essential step in the direction of that great invention, and one intimately connected with its ultimate development. This investigation was made by Bunsen, and communicated to Berzelius in a letter bearing the date

Aug. 7, 1844. The Swedish chemist reported it to the Stockholm Academy (Œfversigt af kongl. Vet. Akad. Förh., (1844) i, 144,) and reprinted his report in his well-known "Jahresbericht über die Fortschritte der Chemie," (1845) xxv, 20. Translated the report reads as follows:—"Bunsen states, that the electric discharge between copper poles is blue, and that it shows the Fraunhofer lines beautifully, when observed by help of a tube through a prism. When other metals are employed, these lines are exhibited very differently and in marvellous variety. By throwing the image on a white wall by means of a *camera obscura*, the phenomena can be followed with the greatest exactness."

There is certainly no lack of clearness in this description, yet every one whom the subject interests will be glad to read the following translated extract from a letter written in answer to my inquiries, and dated 28th July, 1878. Bunsen writes:—"When I made that communication to Berzelius, more than thirty years ago, I regarded these lines, as did every one at the time, as a consequence of the lack of certain kinds of light in the sources of light. In writing that the electric discharge between metallic poles 'showed the Fraunhofer lines wonderfully well,' I can therefore at that period have referred only to the dark lines between the bright ones, and by no means to the reversed, bright and true Fraunhofer lines. This is sufficient to show that, in the observations made at that time, I had as little idea as any one else at the period, of the fundamental constancy of the lines of glowing gases, to say nothing of any suspicion of the transformation of bright lines into dark ones."

It is superfluous to predict that others will ascribe to this research a very different degree of importance from that indicated by the investigator who made it.

II. Geology and Mineralogy.

1. *Oil-well Records in the Northern or Bradford Oil regions, Pennsylvania.*—A paper by C. A. Ashburner, of the Geological Survey of Pennsylvania, published in the Proceedings of the American Philosophical Society, contains records of recent well-borings in McKean and Elk Counties, the Northern or Bradford oil-regions. Among them, that of the well of Dennis & Co., in the former county, to the southwest of Bradford, is of special interest on account of the exact register it gives of the kinds of beds passed through by the drill. A complete description of the rocks will be published in Mr. Ashburner's forthcoming Report of Progress. The elevation of the top of the well above sea-level is 2,055 feet; and the rock about the mouth is the Olean conglomerate, or the bottom of the Millstone grit, called the Coal conglomerate, No. XII, in Pennsylvania geology. Its depth is 1,719 feet. The boring took place in December, 1877 and January, 1878, and the record, which was kept by Mr. Arthur Hale, aid to J. F. Carll, Assistant Geologist in the Geological Survey, is the longest *de-*

tailed and accurately measured record of any oil-well in the United States. The oil-producing sand (sandstone) belongs to the Chemung period, or the upper part of No. VIII. in Pennsylvania geology. A letter to the editors from Mr. Ashburner contains the following statements respecting it. One object in view was to determine the exact stratigraphical relations between the "Third oil-sand" along Oil Creek, Venango Co., and the producing oil-sand at Bradford. Mr. Carll ascertained, in 1875, that the two were different, and that the former was stratigraphically several hundred feet above the latter. In his Report of Progress, the top of the Oil Creek "Third sand" is stated to be about 750 feet below the bottom of the Second Mountain sand, which is probably the equivalent of the Olean conglomerate in my records. The Bradford producing sand is 1,780 feet, more or less, below this latter horizon, so that if the measures neither increase nor diminish in thickness between Bradford and Oil City, the Bradford producing sand would be about 1,000 feet below the "Third sand" along Oil Creek. We are sure that the rocks maintain a constant thickness between these two points.

The paper of Mr. Ashburner gives the records also of the Kinzua Well, 1,768 feet deep; the Wilcox Well, No. 2, or Schultz Gas Well, 2,004 feet deep; the Wilcox Well, No. 3, 1,808 feet deep; the Ernhout and Taylor Wells, Nos. 1 and 2, the latter 2,000 feet deep; the Bear Creek Well, 1,998 feet; the Silver Creek Well, 1,760 feet.

It states, concerning the Schultz Gas Well, that gas issued in immense quantities from a depth of 1,776 feet. An inch pipe was inserted to a depth of 2,000 feet, and the mouth of the well closed with the hope of causing the gas to force out the oil from the latter depth. Two or three barrels of oil were thus obtained; and if, as Mr. Schultz believes, the tube was entirely filled with the oil, the pressure of the gas was sufficient to raise a column of oil an inch square in section and 2,000 feet high. This great pressure was sustained but for a few moments; the gas probably became thoroughly mixed up with the oil, which from its low temperature quickly congealed and effectually choked the pipe." After a few hours the gas ceased entirely; but after thirty-six hours, it commenced to flow again with great energy. There was a sudden increase of the pressure in the early part of 1877. Four months later the flow of gas ceased, but in July 14th it began again to flow; and "up to the present time the amount of gas increases and diminishes at irregular intervals." The gas was used in drilling the Wilcox Well, No. 3.

2. *Region of the Great Lakes.*—Mr. GEORGE MAW, F.L.S., mentions (Geol. Mag., Oct., 1878) facts connected with the level and depth of the Great Lakes, and of glacial phenomena about them, (stating, among other things, that the bottom of Lake Ontario is 365 feet below the sea-level and 600 feet below its own outlet into the St. Lawrence; of Erie, 462 feet above the same; of Huron, 145 feet above; of Lake Superior, 65 feet below the

sea-level); and concludes that the idea of the excavation of Ontario to a depth of 600 feet by glacier action is wholly untenable, and that the theory of glacial excavation for the chain of large lakes must be set aside, in which he is plainly right; and he concludes that *the lake depressions are of post-glacial origin.*

3. *On the occurrence in North America of rare Extinct Vertebrates found fragmentarily in England.*—Professor R. OWEN has a paper with this title in the Annals and Magazine of Natural History for September, 1878. It treats first of the "Restoration of *Chondrosteosaurus*," to which he refers Cope's *Camarosaurus*, and secondly of the Restoration of *Coryphodon*. In the remarks on the latter genus, first established by Professor Owen, the author brings out many points of interest, and gives credit to Professor Marsh's discoveries for the chief part of the facts upon which they are based. The paper has the following concluding sentence. "To the close and careful comparisons of the conscientious palæontologist of Yale College, we are indebted for the above interesting and unexpected additions to our knowledge of the rare and ancient Tertiary mammal, fragmentarily indicated in the 'plastic clay' of England (1845) and in the 'conglomérate de l'argile plastique' at Mendon, France (Hébert, 1856), of the elements toward a restoration of which we might have long remained in doubt had they continued to be made known to us as parts of a *Bathmodon* or *Loxolophodon.*"

4. *On the Erupted Rocks of Colorado;* by J. M. ENDLICH. 572 pp., 8vo. From the 10th Annual Report of the United States Geological Survey under Dr. F. V. Hayden, United States Geologist-in-charge.—Mr. Endlich classifies and describes the eruptive rocks of Colorado, their relation to the veins of ore, their age and origin.

5. *Analyses of Saussurites.*—The following are the references for the analyses cited on page 341.—1. T. S. HUNT, this Journal, II, xxvii, 345, 1859; 2, FIKENSCHER, J. pr. Chem., lxxxix, 456, 1863; 3, HÜTLIN & PFAFFIUS, Verh. Ges. Freib. im Br., ii, 1861; 4, DELESSE, Bull. Soc. Geol. de France, II, vi, 547, 1849; 5, of a specimen from Neurode, Silesia, VOM RATH, Pogg. Ann., xcv, 555, 1855; 6, C. F. CHANDLER, Inaug. Dissert. Gött., 1856 (from Zobten, Silesia); 7, 8, of a lavender-blue variety, in euphotide of the Isle of Unst, M. FOSTER HEDDLE, Min. Mag., Truro and London, April, 1878; 9, DELESSE, Ann. d. Mines, IV, xvii, 116, 1850; —10, DAMOUR, C. Rend., lvi, 861, 1863; 11, L. R. FELLENBERG, Nat. Ges. Bern., 1865, 112; 12, of a saussurite hatchet from near Gerlafingen on Bieler See, Switzerland, Fellenberg, Verh. d. Schweiz. Ges. Solothurn, 1870 (G.=3·2978).

The analysis of the Orezza saussurite by Boulanger appeared in the Ann. des Mines, III, viii, 159, 1835; he obtained SiO_2 43·6, AlO_3 32·0, MgO 2·4, CaO 21·0, K_2O 1·6=100·6. He also analyzed a saussurite from Mt. Genèvre, obtaining SiO_2 44·6, AlO_3 30·4, MgO 2·5, CaO 15·5, Na_2O 7·5=100·6, showing an approximation to Delesse's results and a composition near that of

labradorite; but G.=2·65; it was therefore in the feldspar, and not the saussurite, state. The occurrence of labradorite and saussurite in a euphotide, and transitions from one to the other, appear to be not uncommon.

An analysis of a saussurite from euphotide in Norway near Bergen, afforded Th. Hjortdahl (Nyt. Mag. Nat. Christiania, and Groth's Zeitschr., 1878, 305), SiO_2 42·91, AlO_3 31·98, FeO 0·19, MgO 0·81, CaO 20·94, Na_2O 2·32, K_2O 0·18=99·33, with G.=3·19. It differs little from other analyses of saussurite of the *first* kind, or true saussurite, excepting in the small amount of magnesia.

Although jadeite is not yet known to be one of the euphotide minerals, the specimens being thus far only polished implements or ornaments, its analyses are of interest in this connection, and the following are here added:

	1. Morbihan.	2. Emerald-green.	3. Thibet.	4. Red, China.
SiO_2	58·62	59·66	58·28	60·22
AlO_3	21·77	22·86	23·00	22·58
CrO_3	----	0·14	----	----
FeO	1·86	0·42	4·94	1·59
MnO	0·28	----	*trace*	0·65
MgO	2·23	2·41	1·04	1·15
CaO	3·85	2·27	3·06	1·53
Na_2O	11·64	12·87	9·23	12·60
K_2O	----	----	*trace*	----
Ign.	----	----	----	0·11
	100·25	100·63	99·55	100·70
	G.=3·344	G.=3.330	G.=3·25	G.=3·3456

Nos. 1 and 2 are by Damour, C. Rend., lxi, 1865, p. 361; 3, by Fellenberg, Verh. d. schweiz. Ges. Solothurn, 1870; 4, Eckstein, in H. Fischer's work entitled "Nephrit und Jadeit," Stuttgart, 1875, p. 375.

Th. de Saussure's paper in which he gave the name *Saussurite* to the "Jade" which his father had described (in his Voyages dans les Alpes, i, §112 and v, §1313) is contained in the Journales des Mines, xix, 206, 1806. Further study will probably result in dividing up euphotide according to the kind of saussurite present.

J. D. D.

6. *On Leucoxene in the New Hampshire Diorites;* by G. W. Hawes. (From Mr. G. W. Hawes's Report on the Mineralogy and Lithology of New Hampshire.)—In this Journal, volume xii, at page 134, I described certain reticulated appearances in the "Greenstones" of New Hampshire, as probably of organic origin. These forms were the result of a species of decomposition to which titanic iron is peculiarly subject, and the structure was produced by the cleavage or lamination of the mineral. The product of the decomposition is a grayish white substance, the composition of which is not well established. It was called leucoxene by Gümbel. Sandberger and von Lasaulx regard it as a lime titanate, which results from a reaction between the titanic acid and the lime of the hornblende and feldspars. Cohen suggests that it is pure titanic acid, which view is favored by Rosenbusch. But whatever the substance may be proved to be, the forms observed are the result of the decomposition of titanic acid.

7. *The association of Pyroxene and Hornblende;* by G. W. Hawes. (From Mr. G. W. Hawes's Report on the Mineralogy and Lithology of New Hampshire.)—Though any material capable of forming pyroxene may, under other circumstances, crystallize in the form of hornblende, yet when the two species are so associated as to indicate their formation under the same circumstances, chemical composition must determine the species. This intimate association of the two minerals is frequent in certain eruptive rocks, and some New Hampshire diorites furnish very marked examples in which both species are well crystallized.

The following analyses of associated pyroxene and hornblende from Edenville, N. Y., at which place material in a state of purity can be obtained for analysis, were made for the purpose of discovering what chemical differences had affected the crystallization. The following were the results:

	Hornblende.	Pyroxene.
Silica	42·97	51·05
Alumina	11·90	2·02
Iron sesquioxide	3·08	1·30
Iron protoxide	13·84	12·18
Manganese protoxide	·48	·12
Magnesia	11·49	10·02
Lime	11·63	22·07
Soda	2·73	----
Potash	·88	----
Ignition	·38	·34
	99·38	99·10

The association of pyroxene and hornblende has been noticed by vom Rath in the Vesuvian lavas, where they were formed by sublimation. (See Pogg. Ann. Band Ergänzung, vi, 229.) The analyses were imperfect on account of the small amount of material, but it is interesting to observe that they show the same differences; that is, the hornblende contains a larger percentage of alumina, a smaller of lime, and some alkali which is absent in the pyroxene.

8. *Die Mineraliensammlung der Kaiser-Wilhems-Universität Strassburg, ein Supplement zu den vorhandenen mineralogischen Handbüchern* von P. Groth. 271 pp. 4to, with six plates. Strassburg, 1878 (Karl J. Trübner).—Professor Groth, during his six years' connection with the University at Strassburg, has succeeded in bringing together a mineralogical collection which ranks very high both as regards the number of specimens and their individual excellence. The catalogue which he has recently published contains the results of a very minute study of the collection, giving a description of each specimen with its locality and a determination of the form when crystallized. The work contains much that is new and valuable, and in some cases, as for instance manganite, the description is in fact a monograph of the species giving, many new planes with a large number of figures. The volume is thus a valuable contribution to mineralogical literature. E. S. D.

9. *Mineralogische und Petrographische Mittheilungen*, herausgegeben von G. TSCHERMAK. New series, vol. i, Vienna, 1878.—The "Mineralogische Mittheilungen," which, under the editorship of Professor Tschermak, have appeared since 1871 in connection with the publications of the Austrian "Geologische Reichsanstalt, have occupied an important place among mineralogical publications. With the present year a new series has been commenced, and in future the Journal will be published independently in yearly volumes of six numbers each. Its scope is at the same time enlarged both as regards original articles, and in the summary given of mineralogical work published elsewhere, which forms an important part of each number. Its usefulness will be much increased by the change. E. S. D.

10. *Brief notices of some recently described minerals*:—

Friseite. Occurs in dark-brown orthorhombic crystals with perfect basal cleavage; translucent and sectile. H.=2–3, G.=4·217. An analysis gave S 37·4, Ag 29·1, Fe 33·0=99·5, for which the formula $Ag_6Fe_{13}S_{26}$ is obtained. It is very closely related to sternbergite both in crystalline form and in composition, and the propriety of giving it a new name may well be questioned. Locality, Joachimsthal in Bohemia.—(Vrba, Zeitschrift für Krystallographie, ii, 153).

Hibbertite. Occurs as a loose powder of a lemon yellow color imbedded in purple kammererite. The percentage composition obtained for it after the deduction of the kammererite, from which it could not be entirely separated, is as follows:—CaO 28·46, MgO 26·55, FeO 3·23, MnO 0·58, CO_2 25·44, H_2O 15·73. The name is given only provisionally, as the character of the mineral is not yet established. Locality, Island of Unst (Shetland Isles).—(Heddle, Mineralogical Magazine, ii, 24).

Hullite. A soft velvet-black mineral, with a dull waxy luster. It occurs filling cavities in the basalt of Carnmoney Hill, near Belfast, Ireland. An analysis afforded:—SiO_2 39·43, AlO_3 10·35, FeO_3 20·72, FeO 3·69, MgO 7·47, CaO 4·48, H_2O 13·61, CO_2, MnO, *tr.* =99·77. It seems to be allied to delessite.—(Hardman, Nature, Sept. 5, 1878).

Stützite. Observed in lead-gray highly modified crystals on a specimen of gold from Transylvania (probably Nagyag). The crystals are referred to the monoclinic system, though the symmetry is closely that of the hexagonal system. Contains tellurium and a high percentage of silver, the composition being probably expressed by the formula Ag_4Te=tellurium 22·5, silver 77·5. The crystalline form is closely related to that of dyscrasite and chalcocite.—(Schrauf, Zeitschrift für Krystallographie, ii, 245.)

Pseudobrookite. Occurs in minute tabular crystals belonging to the orthorhombic system; cleavage brachydiagonal distinct. H.=6. G.=4·98. Color dark-brown to iron-black, but in the thinnest crystals brown to red, translucent. Luster adamantine. An analysis afforded TiO_2 52·74, FeO_3(AlO_3 tr.) 42·29, CaO and MgO 4·28, ignition 0·70; according to this the mineral has the

same composition with menaccanite, from which it differs in crystalline form.—(Koch, Min. u. Petr. Mitth. i, 1877.)

Szaboite. Occurs in minute, exceedingly thin, triclinic crystals, which approach the form of pyroxene quite closely. H.=6 and above. G.=3·505. Color hair-brown, in some crystals brownish to hyacinth red; opaque to translucent. An analysis afforded:— SiO_2 52·35, FeO_3 44·70, (AlO_3 tr.), CaO 3·12, MgO, Na_2O tr., ignition 0·40. The mineral is more or less closely related to babingtonite.—(Ibid.) E. S. D.

11. *Geology of New Hampshire.*—The third volume of this Report, recently issued, contains the reports of W. Upham on drift, and of G. W. Hawes on mineralogy and lithology, already noticed, and also chapters on Glacial Drift and on Economic Geology, by C. H. Hitchcock.

The Atlas of the Survey has also appeared in seventeen sheets very large folio, giving the topography, views, profiles, sections, distribution of glacial phenomena, and maps of the geology as made out by the Survey. The coloring is well done.

The Atlas illustrates several interesting points in the geology of Northern New England. It shows that the region of Northern New Hampshire has *Lower Devonian* rocks (Oriskany and Helderberg) just east of its eastern boundary, near latitude 45°, south of Kennebago Lake, in Maine, the age of these rocks being proved by their fossils; that to the westward a degree and more, and just north of lat. 45° (45° to 45° 20′), east of and near Lake Memphremagog, there are also *Lower Devonian* rocks, fossil corals being abundant in calcareous beds which alternate with Helderberg slates that are equivalents of the Gaspé sandstone; and that between these fossiliferous areas of the eastern and western borders of New Hampshire, over Coös County, there are broad, parallel, nearly north and south, belts of "Calciferous mica-schist," the "Coös group," the "Lyman group" and the "Lisbon group," besides strata of clay slate.

The Atlas also shows that the usually associated Calciferous mica-schist and Coös group extend from the Lake Memphremagog region, southward, along the Passumpsic and Connecticut River Valleys, the western border of New Hampshire, to and beyond the southern extremity of the State; that in the Connecticut valley, one-third of the way to the south extremity, at Littleton and Lisbon, there occurs a *Lower Helderberg* (Upper Silurian) limestone, semi-metamorphic, whose age is determined by its fossil corals and brachiopods, and near by are Coös, Lisbon and Lyman beds; and at the south extremity of the State, just west of the southwest angle, there is again *Lower Helderberg* limestone—that of Bernardston—the semi-metamorphic beds of which contain large crinoidal remains.

The writer's observations prove that the Bernardston limestone group* embraces, within a few miles northeast of Bernardston,

* See this Journal, III, xiv, 379, 1877.

mica and hornblende schists, staurolitic schist, quartzyte and other rocks, all lying conformably and alternating with one another; and that these rocks are similar in lithological character to the mica and hornblende schists and quartzyte of the valley to the north; and, that part of them, as Professor Hitchcock asserts, are identical with his Coös slates, indeed, so closely identical that the Bernardston mica schist is made by him Coös. The latter has stated also that the Calciferous mica schist belongs with the Coös.

In view of these facts there is little reason to doubt (1) that the region of New Hampshire in its large northern portion across from east to west is of Lower Devonian and Silurian age; (2) that south of Lake Memphremagog, along the Passumpsic and Connecticut valleys down to Massachusetts (if not farther), the rocks are of Lower Helderberg age and perhaps partly of Lower Devonian; that thus New Hampshire has Paleozoic formations not older than Upper Silurian on its northeastern, northern, and all its western borders; and that the White Mountain region occupies the space between,—Mt. Washington being not twenty miles east of Littleton. These conclusions are those of Sir William Logan's geological map.*

As to the geological age of the region of the White Mountains and that south of it, the map gives nothing definite. Professor Hitchcock's report, (the closing pages of vol. II)† makes the Bethlehem gneiss, the Lake Winnipiseogee gneiss and the porphyritic gneiss, Laurentian; the Montalban schists (mica schists, etc., of the White Mountain region) Upper Laurentian; and the Lyman and Lisbon groups, and the hornblende schist formation, Huronian. In the east-and-west section across the State between the parallels of 44° and 44° 10′, published on one of the geological maps of the Atlas, the Bethlehem gneiss (so-called Laurentian) is shown to be *conformable* in its bedding to the Lisbon Group; and the latter, conformable to the Coös and Calciferous mica schist. Again in a section running across between the parallels 43° 50′ and 44°, the Lake Winnipiseogee and Bethlehem gneiss are conformable to one another and to the staurolitic schists of the Coös, and the latter to the Calciferous mica schist. Again, in a section between the parallels 43° 40′ and 43° 50′ the Montalban schists and Bethlehem gneiss are conformable, and the latter is made conformable in Moose Mountain with the staurolite schists of the Coös; and east of Hanover, this conformability is repeated, and the Coös is made conformable with the Hornblende schist, Lisbon group, clay slate, Calciferous mica schist, and the Coös farther west. Thus there is no evidence in the stratification, according to these sections, that the so-called Laurentian and Huronian are any older than the Coös and Calciferous mica schist of the Connecticut valley;

* The statement on some of the maps—"Sillery, Lauzon, Lewis: Logan's arrangement of the Upper Huronian in Canada and Vermont," is misleading to those not familiar with the facts, since Logan made these formations "*Lower Silurian*," and not "*Upper Huronian*;" and Mr. Hitchcock meant to say Logan's subdivisions of what he *himself* refers to the Upper Huronian.

† This Journal, III, xiv, 316.

and therefore, whether Laurentian, Huronian, or whatever the age, the sections afford nothing to sustain the conclusions as to age, based on the lithological characters of the rocks, put forth in Professor Hitchcock's Report. The evidence, as it stands, is strongly in favor of making the Coös and Calciferous mica schist, with the Lisbon and Lyman groups and the Hornblende schist, of the age of the Lower Helderberg, if not also partly Upper Helderberg. It leaves the age of the gneissic rocks wholly undetermined. There is as yet no good evidence as to the existence, or not, ot Laurentian or Huronian rocks in New Hampshire. J. D. D.

12. *Manual of Mineralogy*, by JAMES D. DANA.—A new, and mostly rewritten, edition of this small Manual of Mineralogy will be published by Wiley & Sons, New York, in November.

III. BOTANY AND ZOOLOGY.

1. *Ueber apogame Farne und die Erscheinung der Apogamie im allgemeinen;* by A. DE BARY. *Botanische Zeitung*, July 19th, 1878, et seq.—The article bearing the above title contains the substance of the address made by Professor De Bary at the annual meeting of German naturalists held in Munich in the autumn of 1877, and the results of his observations on the non-sexual reproduction in ferns as first described in the Botanische Zeitung of 1874. In the last named paper [by Dr. Farlow], it was shown that, in some cases, the prothalli of *Pteris Cretica*, instead of the usual growth from a fertilized archegonium-cell, produced ordinary buds, from which the new fern plant developed without any sexual action whatever. The observations now published by Professor De Bary were made with the intention of ascertaining more in detail the frequency with which the non-sexual mode of reproduction occurred in ferns, and its relation to similar processes in other groups of the vegetable kingdom. He found, on sowing the spores of *Pteris Cretica*, obtained both from cultivated plants of that species and from forms which grew wild in Italy, that, in all cases, the prothalli produced only the non-sexual buds to which he gives the name of "Farlowsche Sprossung." In the few cases where antheridia, archegonia, and the normal embryonic development apparently occurred, he found, by watching the further development of the fern, that the prothalli were not those of *Pteris Cretica*, but came from the spores of other species which had accidentally found their way into the cultures. Of the different species studied by De Bary, in thirty-four, exclusive of varieties, only the normal development by embryo-formation in the central cell of the archegonium was observed; in three, *Aspidium Filix-mas*, var. *cristatum*, *Aspidium falcatum*, and *Pteris Cretica*, only the non-sexual budding. The prothalli of *Pteris Cretica* may or may not contain antheridia. When present they have the same structure as in the typical *Polypodiaceæ*. In by far the majority of cases there are no traces of archegonia, even in a rudimentary condition. Out of hundreds of cases, only seven were found with archegonia, and they all aborted. *Aspidium Filix-mas* per-

fectly resembles *Pteris Cretica* in the distribution of antheridia and archegonia, but in *Aspidium falcatum* archegonia occurred in at least 25 or 30 per cent of the prothalli. Although in the cases observed they had all aborted, De Bary thinks it possible that cases may occur in which the normal embryo-formation takes place, which is hardly possible in the two species first named.

The budding process, in all three cases, consists in the formation of a protuberance on the under surface of the prothallus, from which grow a first leaf, root, and stem-bud, as in the normal embryo-formation, although their relative position and date of development varies. The protuberance is generally found just back of the sinus, where the fertilized archegonium normally occurs. Variations were seen in which the first leaf grew from the upper surface of the prothallus and, at times, two leaves were produced, one on the upper and one on the lower surface. Secondary forms may be produced upon elongations of the lateral lobes of the prothallus. Some of the more peculiar forms are figured in the plate which accompanies the article. In the three species under consideration, as the normal reproduction by an embryonal growth has been lost, and another, non-sexual form of reproduction has taken its place, we may infer that they have descended from some ancestral form in which the sexual mode of reproduction existed. This is illustrated by the case of *Aspidum Filix-mas*, var. *cristatum* which is undoubtedly derived from the typical *Aspidium Filix-mas*, in which only sexual reproduction is known. If, however, we adopt the view recently advanced by Pringsheim, that ferns were originally composed of "Bionten," some of which were sexual and some non-sexual, and which alternate, more or less regularly with one another, we must consider that, instead of having acquired a new power, the ferns which reproduce by budding represent a case of atavism.

De Bary gives the name of *Apogamy* to this substitution of some other form of reproduction in cases where the power of sexual reproduction has been lost. This condition is found in all parts of the vegetable kingdom, and occurs in single species, or groups of species, whose nearest allies reproduce normally. Apogamy is of three kinds: *Apogeny*, where the function of both male and female organs is destroyed; *apogyny*, loss of reproductive power in the female, *apandry*, in the male organ.

Chara crinita is a good instance of apandry with parthenogenesis, that is, of regular embryo-formation from an unfertilized ovule. The female of this species is alone known in northern Europe, yet it fruits abundantly. It has been studied by De Bary in specimens artificially grown in his laboratory; and there is no doubt that here it is not a question of the partial suppression, but of the total loss of the male organs. In ferns we have the best instance of a substitution of a shoot for the normal sexual growth. To the same category belong some of the mosses usually called sterile, that is, destitute of capsular growths. In the mosses, however, it is a question not yet settled whether there is a total loss or only a partial suppression of sexual reproduction.

In *Funkia* and *Allium fragrans*, in the seeds in which Strassburger discovered adventive embryos, we have something similiar to the apogamous ferns; first, in the presence of apparently regularly formed but functionless female organs; secondly, in the presence of apparently active pollen, and thirdly, in the substitution of adventive embryos for the regular embryo-formation. *Citrus* and *Cœlebogyne*, in which Strassburger also found adventive embryos, probably belong to the same class as *Allium* and *Funkia*, as may, also, species like *Euonynuss latifolius*, many *Ardisiæ*, etc., in which polyembryony often occurs. To these are to be added the numerous species, varieties, and races of cultivated plants which rarely produce seeds, but instead have a correspondingly richer reproduction by shoots. If, as seems tolerably certain, sexual reproduction is requisite to the constant propagation of species, we must regard apogamy as a degenerate condition, in which the conditions of propagation are unfavorable. In this connection, however, we must not overlook the fact that in species with budding or non-sexual reproduction, this offspring is produced in surpassing profusion. W. G. F.

2. TODARO, *Relazione sulla Cultura dei Cotoni in Italia, sequita da una Monograpia del Genere Gossypium.* Rome and Palermo, 1877–78. 287 pp. oblong 4to, with atlas of 12 colored plates in large folio.—This work is published apparently by the Italian Government, as an illustrative accompaniment to its exhibition of cotton at the Paris Exposition. In illustration of the species it rivals the monograph of the late Parlatore, though the atlas is not on so large a scale; and the letter-press is much more elaborate. Fifty pages are given to the account of Italian cotton culture; the remainder of the volume to a monagraph of Gossypium, and the history of the genus. Prof. Todaro's views of the species, and of the extent of the genus, may be gathered from the fact that he describes fifty-two species and mentions two other uncertain ones, under four sections, that he includes *Thurberia* under *Eugossypium*, and part of *Fugosia* as well as *Sturtia* under other sections. The former, under the name of *Gossypium Thurberi* Tod., is associated in a subsection, *Anomala*, with a Javanese and an African species, which combine the habit of Cotton with narrow involucral bracts. The author, indefatigable as he has been in compilation, was not aware of the identification of *Thurberia* with the obscure old genus *Ingenhousia;* but *I. triloba* is the same plant. A. G.

3. *The Native Flowers and Ferns of the United States in their Botanical, Horticultural, and Popular Aspects*; by THOMAS MEEHAN, Professor of Vegetable Physiology to Pennsylvania Board of Agriculture, etc. Vol. I. Illustrated by chromolithographs. Boston: Prang & Co., 1878. 192 pp., plates 1–48.—The first volume of this work being now completed and the second doubtless in progress according to the programme, the success of the large undertaking apparently warranting further continuation, it seems due and proper to supplement our notice of the beginning

of the work (in vol. xv, p. 72 of this Journal) with a remark or two upon the completed volume. While congratulating the enterprizing publishers and the ardent editor upon their success, which ensures a full continuance of the publication, we shall, on this very account, freely offer any criticisms that may conduce to its improvement. "Flowers and Ferns in their horticultural and popular aspects" do not here concern us. We dismiss their consideration to the horticultural and the literary press. There is much to interest both, and the plates will interest and satisfy amateurs generally, and more critical botanists not rarely. But the botanical aspects are sometimes taken from a rather high point of view, and the same may be said of some of the botanico-etymological researches. While most may pass without grave dissent, there are morphological and etymological statements which we would be sorry to have set down as specimens of American culture. The morphological and other botanical points to which exception should be taken may pass with this simple *caveat*, as we have no room to discuss them, and to botanists whom we address there is little need. But there are two bits of philology in one number (the sixth) which it would be wrong to pass over, being very characteristic for a tendency to be "wise above what is written."

Sedum has by long prescription been thought to be derived from *Sĕdeo, sedere*, to sit, as on rocks. The editor of the work in hand devotes nearly two pages mainly to the reconsideration of this question, and comes to the conclusion that *sēdo*, to assauge, is the root of the name, Linnæus and the rest to the contrary notwithstanding. To be sure "the name is a very old one and was merely adopted by Linnæus, "who may be all wrong in philology. Still we botanists are not likely to know much better. Tournefort had indeed given his readers the choice of these two derivations; but he did not decide the question. Prof. Meehan decides for *sēdo*, and confirms the opinion by the statement that the *e* in *Sedum* is long. But the Latin dictionaries agree that it is short.

Limnanthemum is thought a badly named genus because its species grow in water rather than in mud or marsh. But the classical meaning of the first member of the word is a pool of standing water and a marshy lake. If "it is properly an aquatic," we should think it properly named. But "our species was named *L. lacunosum*, from the Latin *lacus*, a lake, by Grisebach, author of a Flora of the West Indies, from its actual place of growth, and it might be supposed as a corrective of its generic name. But there are in other countries more species that grow in lakes, so we see there is nothing distinctive in either name, and those therefore who might infer it to be so would be led into serious error." The danger of supposing that the name of a species founded on its place of growth indicates that it is the only species in such places, is not imminent. And only the very few can "be led into serious error" here who have first adopted the notion that *lacunosum* (full of *lacunæ* or pits, as in the lower face of the leaf) is an adjective of *lacus*.

A. G.

5. *Der Zoologische Anzeiger, of* J. V. CARUS.—The recent publication of the Zoological Record for 1876, of the Bericht of Leuckart for the years 1872–75 and of the first numbers of the Zoologische Anzeiger by Carus, naturally suggests an examination of our methods for recording progress in Zoology. We cannot expect either the Jahresberichte which have for so long a time formed one of the annual volumes of the Archiv für Naturgeschichte, or Hofman and Schwalbe's Jahresberichte, or the Zoological Record to appear early enough to be of immediate use to specialists in the course of their investigations. These reports necessarily date back so long that they can only be an indispensable compendium for the general worker who wishes to take up a special subject or see what has been done in the general field.

Some of the recorders have limited their task to a strict analysis of the publications issued within the time included in their record, while others have added to this a running commentary and a more or less favorable criticism. This seems somewhat superfluous, for we can scarcely expect any thing beyond the most limited "notice" in the space at the command of the recorders. In a review of the last Zoological Record in a late number of "Nature" the recorders are all taken to task for not giving greater prominence to Wallace's "Geographical Distribution." What any recorder can find to say in the space at his disposal, which the zoological student has not found out long ago from the work itself, it is difficult to see. And certainly the writer of the notice in Nature hardly expected zoologists to obtain their first information of its publication from the pages of the Zoological Record. The great difficulty under which we all labor is to obtain early information of the articles appearing in the publications of learned societies. These are now so numerous that the majority of our public institutions receive but a small proportion of what is annually published, and what they do receive is issued irregularly and is generally from six to eighteen months in reaching its destination, according to the distance from the point of publication. The question naturally arises: cannot a system be devised by which zoologists will be able to receive by mail early notice of all that is going on, and thus enable them to make special efforts to obtain what they most desire? The Zoologische Anzeiger of Carus seems to us to meet the case. If working naturalists will agree to send to Professor Carus the title of any paper they publish, the moment it is *printed*, giving in a few words also the table of contents and the usual details regarding the number of pages, plates, size, and place of publication, we may hope to be kept informed of all that is going on in Zoology without needless delay. And if Professor Carus could be induced to print the titles on one side of the page, these titles could then be cut up and arranged systematically or alphabetically or both, and no one need remain long in ignorance of what is doing by others. This would probably necessitate giving up the literary notices, but with the large number of zoological periodicals now issued it would not lessen the value of the Anzeiger. A. AG.

6. *Note on Borings of a Sponge in Italian Marble;* by A. E. Verrill.—Some very interesting specimens were recently presented to the Peabody Museum of Yale College, by Dr. I. P. Trimble, of New York. These are fragments of white Italian marble, from a cargo wrecked off Long Island in 1871, and taken up this year. The exposed portions of the slabs are thoroughly penetrated to the depth of one to two inches by the crooked and irregular borings or galeries of the sponge, *Cliona sulphurea* V., so as to reduce it to a complete honey-comb, readily crumbling in the fingers. Beyond the borings the marble is perfectly sound and unalterd. The rapid destruction of the shells of oysters, etc., by the borings of this sponge has long been familiar to me,* but of its effects upon marble or limestone I have not before seen examples, for calcareous rocks do not occur along the portion of our coast which it inhabits. Its ability to rapidly destroy such rocks might have a practical bearing in case of submarine structures of limestone or other similar materials.

7. *Ophiuridæ and Astrophytidæ of the Challenger Expedition, Part I.* By Theodore Lyman. Bulletin of the Museum of Comp. Zoology, vol. v, No. 7. Cambridge. 104 pp. 8vo. 10 plates.—In this important contribution thirteen new genera and ninety-six new species are added to those families included in this part. This shows, very conclusively, that the Ophiuroids, as a group, are largely deep-water forms. The new species are well illustrated and described at length. The new genera are *Ophiomastus, Ophiopyrgus, Ophiocrinus, Ophiotrochus, Ophiophyllum, Ophiobyrsa, Ophiochiton, Ophiocamax, Ophiosciasma, Ophiogeron,* each with one species; *Ophioplinthus, Ophiopyren,* and *Ophiolebes,* each with two species. Of known genera, there are described of *Ophiocten,* 4 species; *Ophioglypha,* 35; *Ophiomusium,* 12; *Ophioceramis,* 1; *Ophiozona,* 4; *Ophioscolex* 2. V.

8. *Synopsis of the Pycnogonida of New England;* by Edmund B. Wilson, Trans. Connecticut Academy of Arts and Sciences, vol. v, Aug. 1878. 26 pp. 8vo, 7 plates.—The North American Pycnogonida have hitherto received very little attention. In this paper fourteen New England species are described, of which five are new. Of the remainder, six are Greenlandic and North European species, and three were described by Dr. Wm. Stimpson from the Bay of Fundy. The genera represented are as follows: *Pycnogonum,* 1 species; *Tanystylum,* 1; *Achelia,* 1; *Pseudopallene,* 2; *Pallene,* 1; *Phoxichilidium,* 2; *Anoplodactylus,* 1; *Ammothea,* 1; *Nymphon,* 4. The species are all illustrated. V.

9. *Proceedings of the United States National Museum,* 1878. Vol. I. 8vo. Washington, D. C.—We have received the first seven signatures of this new serial, which, in general character, resembles the Proceedings of the various learned societies, and contains both brief and somewhat lengthy articles on a variety of zoölogical subjects. Among the articles are several by Mr. W.

* See Report on Invertebrate Animals of Vineyard Sound and adjacent waters, in first Report of U. S. Commission of Fish and Fisheries, 1873, p. 421.

H. Dall, on shells, recent and fossil, mostly of the Pacific coast; several by Mr. G. Brown Goode, and T. H. Bean on Fishes, including a number of additions to the United States fauna; one on the fishes from the Clackamas River, Oregon, by D. S. Jordan; on the birds of Dominica, by G. N. Lawrence; a review of the American species of the genus *Scops*, by Robert Ridgway; on the voices of the Crustacea, by G. Brown Goode. V.

10. *Report on the Hydroida collected during the exploration of the Gulf Stream, by L. F. De Pourtales*; by GEO. J. ALLMAN. Memoirs of the Mus. of Comp. Zoology. Vol. V, No. 2. 66 pp. 4to, with 34 lithographic plates.—In this work a large number of very interesting new genera and species are described and profusely illustrated. The total number of species is seventy-one, of which sixty-four are described as new, the remaining seven being regarded as identical with European or arctic species. The *Plumularidæ* are particularly numerous, comprising twenty-eight species, of which twenty-six are new. Seventeen species occurred in less than fifty fathoms; thirteen between fifty and one hundred fathoms; sixteen between one hundred and two hundred; eight between two hundred and four hundred; and four between four hundred and six hundred fathoms. V.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Report on Bridging of the River Mississippi between Saint Paul, Minn., and St. Louis, Mo.*; by Brevet Major General G. K. WARREN, Major of Engineers. 232 pp. 8vo, with many maps. Washington, 1878.—This Report, after a prefatory chapter on the origin and nature of the investigation of which it treats, gives, in Chapter II, a general account of the Mississippi and Minnesota River Valleys, with maps illustrating the former drainage of Lake Winnipeg southward through these valleys; and in the following chapters, various details connected with the subject of bridging the river. The larger part of Chapter II, which has great geological interest, will be reproduced in another number of this Journal, together with the maps which relate to it.

2. *Report of the Survey of the Connecticut River*, made to the Secretary of War, by Brevet Maj. General G. K. WARREN. 144 pp. 8vo. 1878.—This valuable document consists mainly of the Report of General Theodore G. Ellis, who had charge of the work under General Warren. General Warren, in his preliminary statements, observes that the velocity observations made in the course of the survey (numbering at Thompsonville 1,434) confirm fully the deduction of Humphreys and Abbott (given in their Physics and Hydraulics of the Mississippi) as to the parabolic form of the curve of subsurface velocities. The maximum discrepancy between the requirements of the Humphreys and Abbot formula and the observations is only seven-hundredths of a foot per second. The observations are given in detail in General Ellis's Report, which follows; and as they were made with great

care, and without prejudice in favor of the conclusion reached, they are of the highest importance in the department of hydraulics.

General Ellis also gives the observations made with reference to the monthly and annual discharge of the Connecticut. These observations were carried forward at Hartford, which, although over forty miles from Long Island Sound, is reached by the tides, the amount of tide at the lowest water being about ten inches in range. This discharge for the year 1876 and 1877 was as follows:

	1876. Millions of cubic feet.	1877. Millions of cubic feet.
January	79,956	17,500
February	64,400	18,491
March	93,866	95,253
April	160,756	110,247
May	155,521	45,374
June	41,008	10,907
July	22,016	25,475
August	16,674	22,146
September	17,186	18,089
October	16,930	31,772
November	20,822	75,825
December	17,156	46,382
	700,291	516,261

The highest known freshet on the Connecticut below Holyoke is stated to have occurred in May, 1854, when the water at Hartford gauge stood twenty-nine feet ten inches above low-water mark. The next highest on record—that of 1801—carried the waters up to twenty-seven feet six inches.

The report contains also the results f borings near the Connecticut River Channel at Hartford and to the north up to twenty-five miles. At Hartford and two-thirds of a mile north the depth reached was fifty feet below low water and in the latter case "hard red marl" was struck; at a point 1·56 miles north of Hartford, a boring of 90 feet ended in clay; 2·39 miles north, one of 123·4 feet reached, probably, rock; at 3·37 miles north, rock was reached in 21·11 feet; and at 4½ miles north, rock was reached in 34·8 feet.

3. *Translation of Weisbach's Mechanics.*—The second part of Vol. II of this translation by Professor DuBois (8vo, viii and 559 pp.), contains a full discussion of the important subjects of Heat, Steam and Steam Engines. The first part on Hydraulics and Hydraulic Motors appeared about a year ago (this Journal, xv, 78). Numerous additions to the original work have been made in the form of notes. These are largely by Mr. Richard H. Buel, and are given in order to complete the work in those directions in which there has been recent progress, and to adapt it more fully to American practice.

The third and final volume of Professor Weisbach's great work is now undergoing thorough revision in Germany by Professor Hermann, and its translation will be issued by the publishers

(Wiley & Sons) about the time of the completion of the German revision.

4. *Report of the Superintendent of the Coast Survey, showing the progress of the Survey during the year* 1875. 412 pp. 4to, with thirty charts.—Among the twenty Appendices may be mentioned: Report on Mount Saint Elias, Alaska, by Wm. H. Dall; No. 11, Report on recent observations at South Pass Bar, Mississippi River; Discussion of Tides in New York Harbor, by Wm. Ferrel; Report on the Transit of Venus Expedition to Japan, 1874, by George Davidson; Report on the Transit of Venus Expedition to Chatham Island, 1874, by Edwin Smith; Terrestrial Magnetism, Instructions for magnetical observations, by C. A. Schott.

5. *Eleventh Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology.* Presented to the President and Fellows of Harvard College, September, 1872. Vol. II, No. 2. 458 pp. 8vo. Cambridge, 1878.—This Report contains several memoirs of special value. The first is a Second Report by C. C. Abbot, on the "implements found in the Glacial Drift of New Jersey, occupying over 30 pages. This is followed by others on Cave Dwellings in Utah, Manufacture of soapstone pots by the Indians of New England, Archæological explorations in Tennessee, and other papers of great interest.

6. *A History of the Growth of the Steam Engine;* by R. H. Thurston, A.M., C.E. 490 pp. 8vo. New York, 1878. (D. Appleton & Co., International Science Series.)—A thoroughly readable and instructive discussion of a most interesting subject. The concluding chapter on the "Philosophy of the Steam Engine" gives a concise statement of an important branch of thermodynamics in accordance with modern principles.

7. *Elementary Quantitative Analysis;* by Alexander Classen, Professor in the Royal Polytechnic School, Aix la Chapelle. Translated with additions by Edgar F. Smith, A.M., Ph.D. 328 pp. 8vo. Philadelphia, 1878. (Henry C. Lea.)—In this work the methods of separation required in quantitative analysis are taught by means of examples. The directions for the successive steps in each analysis are given with care and minuteness, and will be found of great value to the student.

8. *The American Quarterly Microscopical Journal, containing the Transactions of the New York Microscopical Society.* Vol. I, No. I. 82 pp. 8vo.—The first number of this new scientific Quarterly, issued under the auspices of the New York Microscopical Society, bears throughout evidence that the Journal will be a valuable record of new discoveries, memoirs, and works in the science to which it is devoted. It contains papers by J. D. Hyatt, H. L. Smith, F. B. Hine, W. H. Seaman, W. T. Belfield, W. Lighton, E. Percival Wright, besides miscellaneous notices and reviews, and is illustrated by seven excellent plates. We commend the Journal strongly to all who are interested in scientific discovery and progress. A very large part of this progress in

recent years has come through microscopic investigation and the same source still continues to be prolific in the profoundest of discoveries.

Mémoires sur les Terrains Cretacé et Tertiaires preparés par feu ANDRÉ DUMONT, pour servir à la description de la Carte Géologique de la Belgique. edités par MICHEL MOURLON, Conservateur au Museé d'Hist. Nat. Tome II Terrrains Tertiaires, Première Patrie. 440 pp., 8vo. Bruxelles, 1878.

OBITUARY.

THOMAS BELT.—Mr. Thomas Belt, F.G.S., of London, England, died in Kansas City, Missouri, on Saturday, September 28. Mr. Belt had been for some time past actively at work in Colorado, looking after the mining interests of some English company. During the same time he has made some interesting notes of the Drift of that State, and in a letter to the writer in August, he informed him of the discovery of a skull of a human being in the Drift, the details of which he was engaged in studying and working out. He was engaged in preparing a paper to be presented to the American Association at the St. Louis meeting, on the subject of the above-named skull, but did not complete his study in time. He has written many valuable papers on geology, especially on glaciers, and also an interesting volume, entitled "The Naturalist in Nicaragua," continued the result of his observations of over two years in that country. One of his papers is on the retrocession of Niagara Falls.

About two weeks previous to his death he had shown signs of insanity, and it was thought best to remove him to New York. Mr. Silas Lloyd, who had been for a short time associated with him, accompanied him. Just before arriving at Kansas City, Mr. Lloyd had occasion to leave him for a few minutes. On returning, he found the door locked. Mr. Belt refused to let him in, and commenced a furious onslaught on furniture and car. Parties crawled through the broken windows and succeeded in pacifying him. Getting him off the train, he was prevailed upon to drink a glass of milk, and about twenty minutes afterward he died.

G. C. BROADHEAD.

DR. E. v. ASTEN; M. E. QUETELET; THOMAS GRUBB.—Astronomy has recently lost several able men by death. One of these was Dr. E. von Asten, who was attached to the Pulkowa Observatory, and who has carried on the discussion of the observations and orbit of Encke's comet since Professor Encke's death. He died August 15th, at Kiel, aged 36. Another loss is that of M. E. Quetelet on the 6th of Sept., at Ixelles at the age of 53. He was assistant at the Brussels Observatory for more than twenty years, the direction of which practically fell on him. One of his many important contributions to science was on the proper motions of certain stars. Mr. Thomas Grubb, the maker of the large Melbourne reflector, and of numerous other large reflectors and refractors, died Sept. 19, in the 78th year of his age.

DR. AUGUST HEINRICH PETERMAN.—Dr. A. H. PETERMANN, the learned geographer, and editor or the "Mittheilungen," died at Gotha, Germany, on the 27th of September, at the age of fifty-six.

APPENDIX.

ART. XLIV.—*Principal Characters of American Jurassic Dinosaurs;* by Professor O. C. MARSH. Part I. With seven Plates.

ON the flanks of the Rocky Mountains, a narrow belt of strata can be traced for several hundred miles, marked always by the bones of gigantic Dinosaurs. Its position is above the characteristic red Triassic beds, and immediately below the hard sandstone of the Dakota group. Hayden, Cope and others have regarded this horizon as Cretaceous, but the abundant vertebrate remains now known from it prove its Jurassic age beyond a reasonable doubt. The writer examined a typical outcrop of this series, on the western slope of the mountains in Wyoming, in 1868, and determined it to be Jurassic; and he has recently named the series the Atlantosaurus beds, from the most striking vertebrates they contain. The strata consist mainly of estuary deposits of shale and sandstone, and the horizon is clearly upper Jurassic, as shown in the accompanying section (Plate IV.)*

Besides the Dinosaurs, which are especially abundant, numerous remains of Crocodilia (*Diplosaurus*), as well as Tortoises and Fishes (*Ceratodus*), have been found, and with them a single Pterodactyle (*Pterodactylus montanus*).† The small Marsupial (*Dryolestes priscus*) recently described by the writer was discovered in the same beds.‡

The remains of *Dinosauria* in this series of strata are mostly of enormous size, and indicate by far the largest land animals hitherto discovered. *Atlantosaurus immanis* must have been at least eighty feet in length, and several others nearly equaled it in bulk. With these monsters occur the most diminutive Dinosaurs yet found, one of them (*Nanosaurus*) being about as large as a cat. The herbivorous Dinosaurs now known from these beds are of special interest, and represent two distinct groups, the more important characters of which are given in the present article.

* This section was especially designed to illustrate an Address by the writer, on The Introduction and Succession of Vertebrate Life in America. This Journal, vol. xiv, p. 337, Nov., 1877.

† This Journal, vol. xv, p. 233, Sept., 1878.

‡ This Journal, vol. xv, p. 412, June, 1878.

SAUROPODA.

A well marked group of gigantic Dinosaurs from the above horizon has been characterized by the writer as a distinct family, *Atlantosauridæ*, but they differ so widely from typical *Dinosauria*, that they belong rather in a suborder, which may be called *Sauropoda*, from the general character of the feet. They are the least specialized of the order, and in some characters show such approach to the Mesozoic Crocodiles, as to suggest a common ancestry at no very remote period.

The most marked characters of this group are as follows:

1. The fore and hind limbs are nearly equal in size.
2. The carpal and tarsal bones are distinct.
3. The feet are plantigrade, with five toes on each foot.
4. The precaudal vertebræ contain large cavities, apparently pneumatic.
5. The neural arches are united to the centra by suture.
6. The sacral vertebræ do not exceed four, and each supports its own transverse process.
7. The chevrons have free articular extremities.
8. The pubes unite in front by ventral symphysis.
9. The third trochanter is rudimentary or wanting.
10. The limb bones are without medullary cavities.

Of this suborder, *Sauropoda*, four genera are well represented in the Museum of Yale College, and others, apparently closely allied, are indicated by remains from this country and Europe described by various authors. The genera *Atlantosaurus*, (*Titanosaurus*),* *Apatosaurus* and *Morosaurus*, have already been described by the writer, and with the new genus *Diplodocus*, defined below, are the most characteristic American representatives of this group. Of these, *Morosaurus* is known from a large number of individuals, including one nearly complete skeleton, and hence, in the present communication, this genus will be mainly used to illustrate the group.

Morosaurus, Marsh, 1878.

The head in this genus was very small. The skull shows in its fixed quadrates and some other features a resemblance to that in the Crocodiles. The rami of the lower jaw are not united by symphysis. The teeth are numerous, and their general form is shown in Plate V, figures 1 and 2. The neck was elongated, and, except the atlas, all the cervical vertebræ have deep cavities in the sides of the centra, similar to those in birds of flight. (Plate V, figures 3 and 5). They are also strongly opisthocœlous. The atlas and axis are not ankylosed together, and the elements of the atlas are distinct. The supero-lateral pieces unite with the axis by zygapophyses, (Plate V, figure 4, z).

* This Journal, xiv, pp. 87, 514; xv, pp. 241.

The dorsal vertebræ have elongated neural spines, and deep ıvities in the sides. They are distinctly opisthocœlous. There 'e four vertebræ in the sacrum, all with cavities in the centra. heir transverse processes are vertical plates, with expanded ıds. The anterior caudal vertebræ are plano-concave, and early or quite solid. The tail was elongated, and the chevrons 'e similar to those in Crocodiles.

The scapula is elongated and very large, and has a prominent ıterior projection. The coracoid is small, suboval in outline, ıd has the usual foramen near its upper border. These two ones are well represented in Plate VI, nearly in the relative osition in which they were found. The humerus is very rge and massive, and its radial crest prominent. This bone nearly solid, and its ends were rough, and well covered with ırtilage. This is true also of all the large limb bones in this enus. The radius and ulna are nearly equal in size. The ırpal bones are separate, and quite short. The five metacar-als are short and stout, and the first is the largest. The toes ere thick, and the ungual phalanges were evidently covered ith hoofs. In Plate VII, figure 1, the restoration of the apular arch and entire fore limb of one species of *Morosaurus*, ell illustrates this part of the skeleton.

The pelvic bones are distinct from each other, and from the ıcrum. The ilium is short and massive, and shows on its ıner side only slight indications of its attachment to the ıcrum. More than half of the acetabulum is formed by the ium, which sends down in front a strong process for union 'ith the pubis, and a smaller one behind to join the ischium Plate VIII, figure 1, *a* and *b*). The acetabulum is completed elow by the pubis and ischium. The pubis is large and tout, and projects forward and downward, uniting with its ellow on the median line in a strong ventral symphysis. Its pper posterior margin meets the ischium, and contains a large oramen. The ischium projects downward and backward, and ı *Morosaurus* its distal end is not expanded for a symphysis. 'he relative position and general form of the three pelvic ones in this genus are shown in Plate X, figure 3.

The femur is long and massive, and without a true third rochanter, although a rugosity marks its position. The great rochanter is obtuse, and placed below the head. The ridge which plays between the tibia and fibula is distinct. The tibia s shorter than the femur. It is without a spine or fibular ridge, nd its distal end shows that the astragalus was separated from t by a cushion of cartilage. The fibula is stout, its two extremi-ies nearly equal, and its distal end supports the calcaneum. The wo tarsal bones of the second row are short, and the five well-leveloped digits are similar to those in the manus. The first netatarsal is much the largest. (Plate VII, figure 2.)

The largest species of this genus at present known may be called *Morosaurus robustus*. It can readily be distinguished from those already described by its short, helmet-shaped, ilium, which is represented in Plate VIII, figures 1 and 2.

One species of this genus, *Morosaurus grandis*,* is now known by a nearly complete skeleton, and the remains here figured are mainly portions of this individual. They were found together in nearly as perfect preservation as in life, and many of them were in their natural position. The locality was in Wyoming, and the bones were taken out with great care by Mr. S. W. Williston of the Yale Museum.

This animal when alive was about forty feet in length. It walked on all four feet, and in many other respects was very unlike the typical Dinosaur. It must have been very sluggish in all its movements. Its brain was proportionately smaller than in any known vertebrate.

Diplodocus longus, gen. et sp. nov.

This genus includes some Dinosaurs of very large size, and herbivorous in habit. It may be distinguished from the genera already known by the caudal vertebræ, which are elongated, deeply excavated below, and have double chevrons, with both anterior and posterior rami. (Plate VIII, figures 3 and 4). To the last character, the generic name refers. The tibia, also, is a very characteristic bone, as it is deeply grooved above to receive the fibula. The feet in this genus are very similar to those of *Morosaurus*, shown in Plate VII.

The present species is based upon one posterior limb, and the tail, of a single individual. The limb, as extended before removal, measured from the head of the femur to the end of the toes over thirteen feet ($4·1^{M}$). The femur was 1645^{mm} in length, and the tibia 1090^{mm}. Four of the median caudal vertebræ measured together thirty-four inches (760^{mm}). The first of these, or the fourteenth in the series, was eight and one-half inches (217^{mm}) long, and five and one-half inches (140^{mm}) across the anterior end.

The peculiar chevron represented in Plate VIII, figure 3, was found attached to the eleventh caudal, and all the remaining chevrons observed were of this character. Figure 4 represents a specimen found at another locality, and perhaps belonging to a different genus.

The above remains indicate a reptile about fifty feet in length. They were found in the upper Jurassic, near Cañon City, Colorado, in 1877, by Mr. S. W. Williston.

* This species, when described by the writer, was referred provisionally to the genus *Apatosaurus*. This Journal, vol. xiv, p. 515.

Laosaurus Marsh, 1878.

Another well marked group of herbivorous Dinosaurs, mostly of small size, occur in the same deposits with the gigantic forms above described. These belong to a separate suborder, and among the typical *Ornithoscelida*, as defined by Huxley. They belong also to the *Iguanodontidæ*, and most nearly resemble the genus *Hypsilophodon*, from the Wealden of England. All the specimens known from the Atlantosaurus beds appear to come under the genus *Laosaurus*, several species of which have already been found, represented by numerous individuals. One of the species hitherto undescribed may be called *Laosaurus altus*, and its remains, with those of the smaller *Laosaurus celer*,* are here used to define the characters of the genus.

The skull is of medium size, and, so far as its structure has been made out, resembles that of *Hypsilophodon*. The teeth, also, are very similar (Plate IX. figures 2 and 3.) The rami of the lower jaw are edentulous in front, and apparently were not united by symphysis. The dorsal and caudal vertebræ have their extremities nearly plane, and the neural arches are united to the centra by suture. The chevrons have their articular ends joined together, as in *Iguanodon* and most Dinosaurs.

The fore limbs were quite small, less than half as long as the hind limbs, and evidently were not much used in locomotion. The humerus is slender, and considerably curved. The radius and ulna are nearly of the same size. In this species, the humerus is 190^{mm} long, and the radius 150.

The bones of the pelvis are distinct. The outline of the ilium is not known, but the pubes and ischia of several individuals have been determined, and prove of great interest. The pubis forms the antero-inferior part of the acetabulum, and the ischium completes the lower portion. The pubis extends downward and inward in front, and terminates in a broad spatulate free extremity. It unites with the ischium below the acetabulum, and sends backward and downward a long slender ramus, which is clearly homologous with the so-called pubic bone in birds (Plate X, figure 2). There is a large foramen near the ischiadic margin. This foramen is closed behind by suture only, and in some specimens becomes a notch. The posterior, rodlike, ramus ossifies from an independent center, and, to distinguish it from the true reptilian pubis in front, may be called the post-pubic bone. A comparison of the three pelves represented together in Plate X (*Hesperornis*, *Laosaurus* and *Morosaurus*), will make clear the intimate relation existing between the pubic bones of Birds and Dinosaurian reptiles.† If this series be extended by adding

* This Journal, xv, 244, March, 1878.

† After these figures were made, showing the position of the Dinosaurian pubis, which has caused so much discussion since Cuvier, I found that Dr. J. W. Hulke had already suggested the true solution of one difficulty. (Journal Geological Society of London, vol. xxxii, p. 334.)

the pelves of some existing birds (for example *Geococcyx*), and of a few other reptiles, it will become still more evident that the bone called "pubis" in a bird, is a different bone from the pubis of a crocodile. The ischium in *Laosaurus* is a slender bone, extending backward parallel with the post-pubic. It has a distinct obturator process, which laps over the latter bone.

The limb bones in this genus have a distinct medullary cavity. The femur has a prominent great trochanter, the extremity of which is separated from the neck by a fissure. The third trochanter is long, and curved outward. The tibia slightly exceeds the femur in length, the proportions in *Laosaurus altus* being 393 to 360^{mm} (Plate IX, figure 3). The fibula is slender, and the distal smaller than the proximal end. The astragalus is distinct from the tibia, and the calcaneum supports the fibula. There are but two tarsals in the second row. There are three well developed digits in the pes (II, III and IV). The outer, or fifth, is wanting, and the first, or hallux, is represented only by a remnant of the metatarsal. The phalanges are rather short, and the ungual ones are pointed. (Plate IX, figure 3.)

The remains of this genus at present known are all from the Atlantosaurus beds of Colorado and Wyoming. Those here described were found in Wyoming by Mr. S. W. Williston. They represent an animal of slender proportions, and about ten feet in length.

Yale College, New Haven, October, 1878.

[To be continued.]

Recent. Post Tertiary.			Tapir, Peccary, Bison, Llama. *Equus. Megatherium. Mylodon.*
Tertiary.	Pliocene.	Equus Beds.	*Equus, Tapirus. Elephas.*
		Pliohippus Beds.	*Pliohippus, Tapiravus, Mastodon. Protohippus, Aceratherium, Bos.*
	Miocene.	Miohippus Beds.	*Miohippus, Diceratherium, Thinohyus.*
		Oreodon Beds.	Edentates (*Moropus*), *Hyænodon, Eporeodon, Hyracodon.*
		Brontotherium B.	*Mesohippus, Menodus, Elotherium.*
	Eocene.	Diplacodon Beds.	*Epihippus, Amynodon.*
		Dinoceras Beds.	*Tinoceras, Uintatherium, Limnohyus, Orohippus. Helaletes, Colonocerus.*
		(Green River B.)	
		Coryphodon Beds.	*Eohippus*, Monkeys, Carnivores, Ungulates, Tillodonts, Rodents, Serpents.
Cretaceous.		Lignite Series.	*Hadrosaurus, Dryptosaurus.*
		Pteranodon Beds.	Birds with Teeth (*Odontornithes*), *Hesperornis, Ichthyornis.* Mosasaurs, *Edestosaurus, Lestosaurus, Tylosaurus.* Pterodactyls, Plesiosaurs.
		Dakota Group.	
Jurassic.		Atlantosaurus B.	Dinosaurs, *Apatosaurus, Allosaurus, Nanosaurus.* Turtles. *Diplosaurus.* Pterodactyls. *Dryolestes.*
Triassic.		Conn. River Beds.	First Mammals (Marsupials), (*Dromatherium*). Dinosaur Footprints, *Amphisaurus.* Crocodiles (*Belodon*).
Carboniferous.		Permian.	Reptiles, *Nothodon, Sphenacodon.*
		Coal Measures.	First Reptiles (?)
		Subcarboniferous.	First known Amphibians (Labyrinthodonts).
Devonian.		Corniferous.	
		Schoharie Grit.	First known Fishes.
Silurian.		Upper Silurian.	No Vertebrates known.
		Lower Silurian.	
Cambrian.		Primordial.	
Archæan.		Huronian.	
		Laurentian.	

SECTION OF THE EARTH'S CRUST.

TO ILLUSTRATE VERTEBRATE LIFE IN AMERICA.

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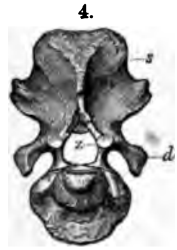

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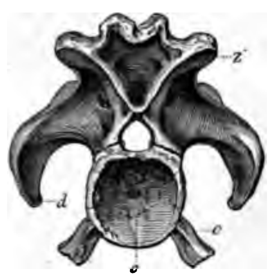
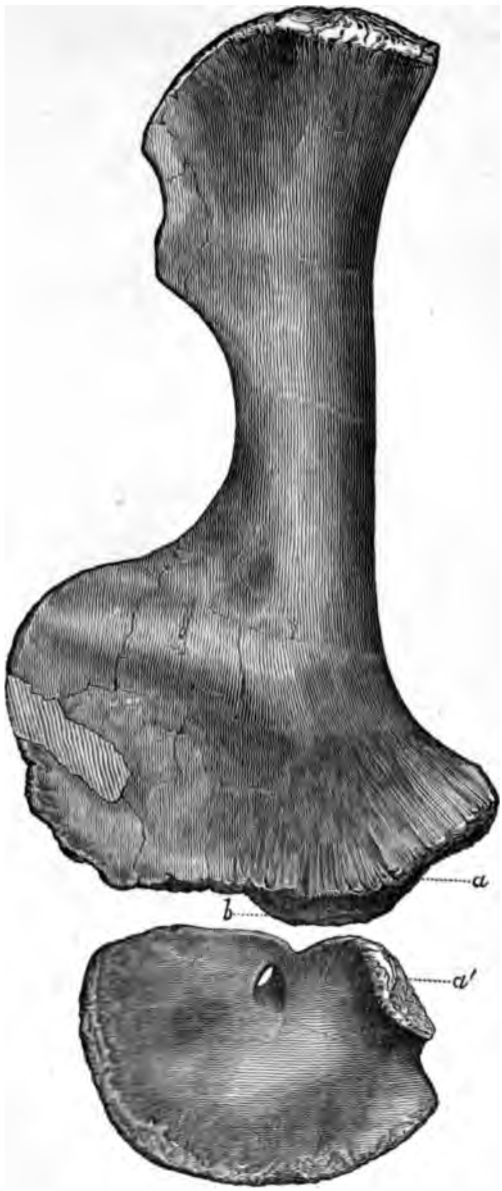


Figure 1.—Tooth of *Morosaurus grandis* Marsh; side view.
Figure 2.—The same; front view. Both one-half natural size.
Figure 3.—Axis and part of atlas of *Morosaurus grandis;* side view, one-eighth natural size. *a.* odontoid process, or centrum of atlas; *ax.* centrum of axis; *f.* foramen in centrum; *s.* neural spine.
Figure 4.—The same; front view. *d.* diapophysis; *z.* zygapophysis.
Figure 5.—Fourth cervical vertebra of *Morosaurus grandis;* side view, one-eighth natural size. *b.* ball on anterior end of centrum; *f.* foramen in centrum: *z.* anterior zygapophysis; *z'.* posterior zygapophysis.
Figure 6.—The same; back view. *c.* cup on posterior end of centrum; *d.* diapophysis; *e,* parapophysis; *z'.* posterior zygapophysis.



Left scapula and coracoid of *Morosaurus grandis* Marsh; side view; one tenth natural size. *a.* scapular face of glenoid cavity; *b.* rugose surface of scapula for union with coracoid; *a'.* coracoidean part of glenoid cavity.

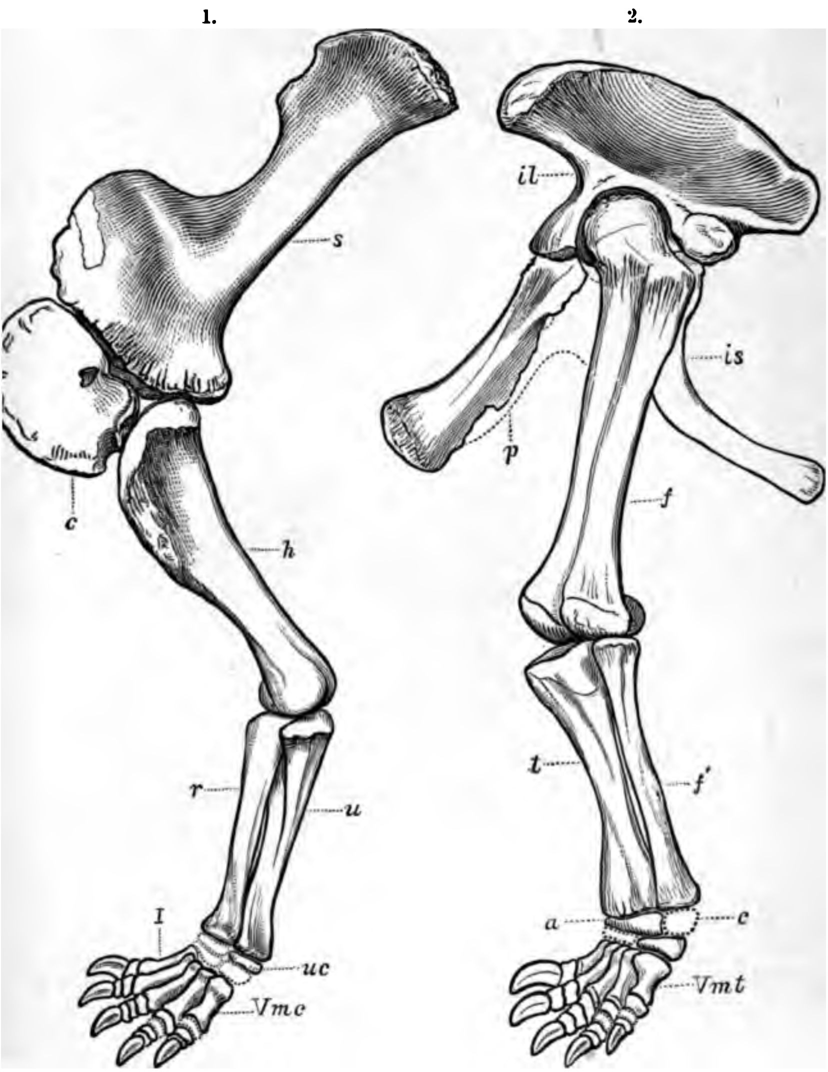


Figure 1.—Bones of left fore leg of *Morosaurus grandis* Marsh; one-twentieth natural size; *s.* scapula; *c.* coracoid; *h.* humerus; *r.* radius; *u.* ulna; *uc.* ulnar carpal; *I.* first metacarpal; *Vmc.* fifth metacarpal.

Figure 2.—Bones of left hind leg of *Morosaurus grandis*; one-twentieth natural size. *il.* ilium *is.* ischium *p.* pubis, *f.* femur; *t.* tibia; *f'.* fibula; *a.* astragalus; *c.* calcaneum; *Vmt.* fifth metatarsal.

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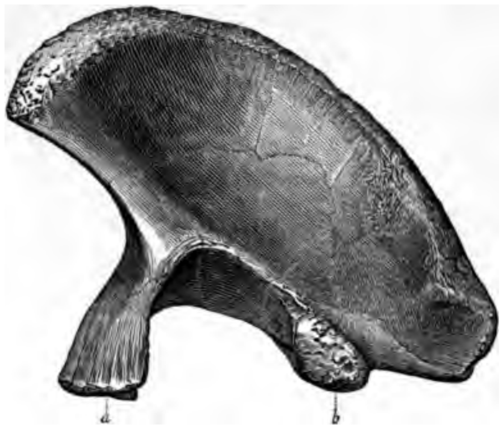

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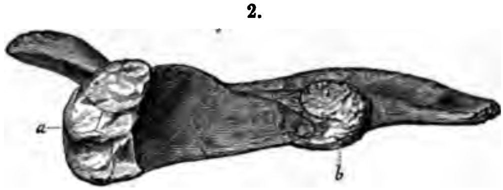

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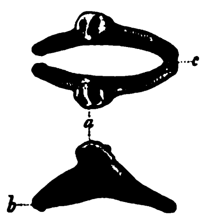

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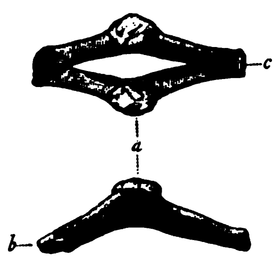

Figure 1.—Left ilium of *Morosaurus robustus* Marsh; side view. *a.* anterior, or pubic, articular surface; *b.* posterior, or ischiadic, articular surface.
Figure 2.—The same; inferior view. *a*, anterior, or pubic, articulation; *b.* posterior, or ischiadic, articulation. Both figures one-tenth natural size.
Figure 3.—Chevron of *Diplodocus longus* Marsh; top and side views. *a.* articular surfaces; *b.* anterior process; *c.* posterior process.
Figure 4.—Chevron of another individual; letters the same as in figure 3. All the figures are one-tenth natural size.

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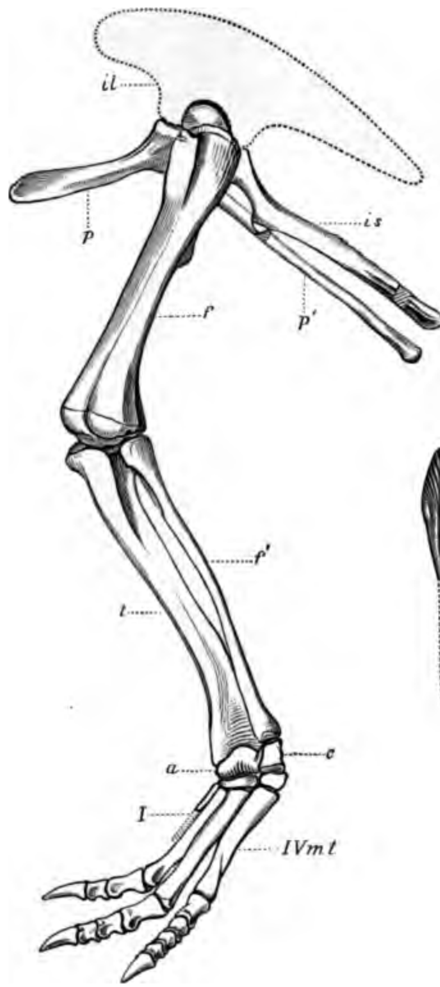

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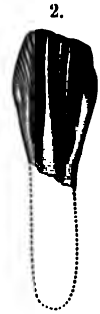

Figure 1.—Tooth of *Laosaurus altus* Marsh; front view.
Figure 2.—The same, side view. Both twice natural size.
Figure 3.—Bones of the left hind leg of *Laosaurus altus* Marsh; one-eighth natural size; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubic bone; *f.* femur; *t.* tibia; *f'.* fibula; *a.* astragalus; *c.* calcaneum; *I.* first metatarsal; *IVmt.* fourth metatarsal.

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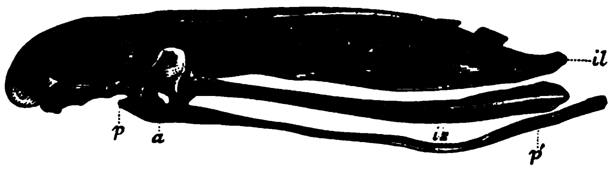

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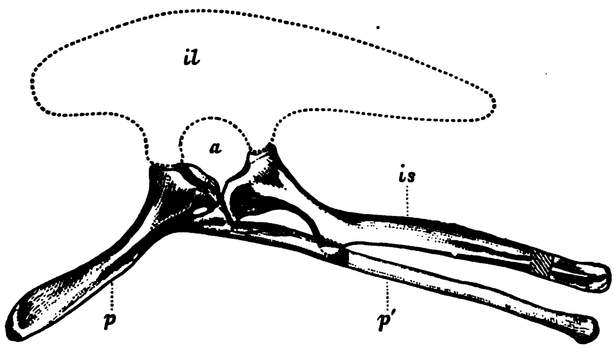

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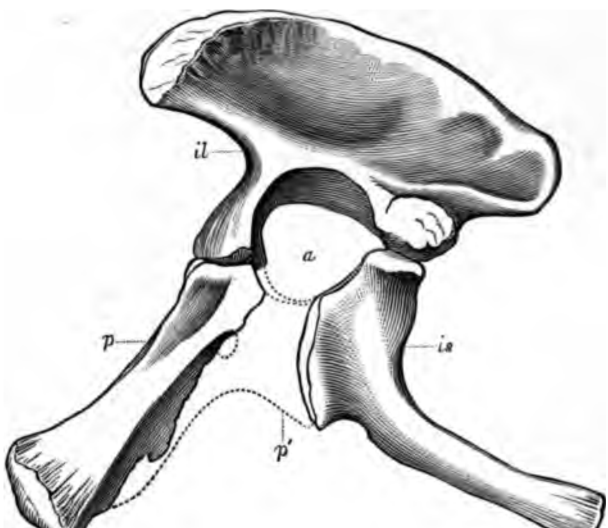

Figure 1.—Pelvis of *Hesperornis regalis* Marsh (Cretaceous); seen from the left, one-fifth natural size.

Figure 2.—Pelvis of *Laosaurus altus* Marsh; seen from the left, one-sixth natural size.

Figure 3.—Pelvis of *Morosaurus grandis* Marsh; seen from the left, one-sixteenth natural size.

The signification of the letters is the same in all the figures, viz: *a.* acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. L.—*Valley of the Minnesota River and of the Mississippi River to the junction of the Ohio: its origin considered;* by Gen. G. K. WARREN, Major of Engineers. With Diagrams A, B, C, C′, D, E, F and G (making plates 11 to 18 of the volume).

Definition of the term "valley," prominent natural features and length.—The *valley* to be considered is the part included between the high banks, commonly called bluffs. Whenever it becomes necessary in this article to refer to the whole area drained by the river, the word *basin* will be used to designate it.

Between these high banks the greater portion is subject to overflow at time of floods, forming what is sometimes called the *flood plain;* the smaller part above overflow is generally composed of alluvial terraces of sand and gravel. In some cases the distinction between the terraces and the bluffs is difficult to make.

The Mississippi River in its usually navigated parts touches only here and there at places exempt from flood-waters, and these are natural landings for steamboats and sites for towns. In course of time the convenience of the people living there makes them desirable locations for bridges. It is very rare, however, that both banks of the river are above submergence; where one bank is, the opposite one is generally low, and covered many feet deep at extreme high-water, making it difficult to construct bridges sufficiently elevated for steamboats to pass under them.

The distance along the general course of this valley from St. Louis to St. Paul is about 620 miles, but steamboatmen, by the course they take along the navigable channels, make the distance

about 800 miles. This was the only part specified in the law authorizing this investigation, but it was necessary in order to present the subject itself properly to include the whole distance from the mouth of the Minnesota to the Ohio; this is an extent of about 760 miles along the general course of this valley, and we have prepared a map of it in twenty-two sheets on a scale of two inches to a mile. The manner in which this is done is described in Chapter VI of this report.

General map and profile prepared for publication.—Although we have, in constructing the map, exhausted all means of obtaining knowledge in regard to this part of the Mississippi Valley, there are some parts of it too little determined to make its publication as a whole, advisable, and therefore we have only prepared for publication the index map of those twenty-two sheets, on a scale of six miles to an inch. (If photo-lithographed it may vary from this scale.) Here, again, generalizations have led us to make this index map include the Minnesota River Valley. That valley, under another clause of the law, was also made a part of my investigation, and a map in twenty sheets on a scale of two inches to the mile was made for it. The map submitted for publication is also an index map to those Minnesota Valley sheets now on file at Engineer headquarters in Washington. We have also extended this general map southward so as to include overflowed land as far as the northern part of Arkansas, and northward to include a part of the basin of the Red River of the North. It is designated as Diagram 1, in five sheets.

The two systems of the United States land surveys, one on each side of the river, are so checked upon each other in its construction and by special surveys by ourselves, that the valley on this small scale is probably as correct as it can be represented. The whole of the flood-plain is shaded with light ruled lines, except the principal lakes and water-courses, which are shaded with heavy lines. The alluvial terraces above overflow are shaded with dots. The high banks or bluffs are without shading. On sheet five there are some overflowed lands that are above the Mississippi floods, which have special shading.

In order to complete a presentation of the Mississippi flood-plain to the Gulf of Mexico, the page Diagram A is added, reduced from Plate II of the report of Humphreys and Abbot on the physics and hydraulics of the Mississippi.

General considerations as to the formation of the Mississippi Valley have caused me to present also the page Diagram B, showing the Mississippi basin as it is, and extending northward to include the Lake Winnepeg basin with the ancient extension of the lake southward and outflow through the valley of the Minnesota and Mississippi Rivers.

Profiles prepared for publication.—Accompanying this chapter are two sheets of longitudinal profiles of the valley from the junction of the Minnesota River to the junction of the Ohio. The horizontal scale is about eight miles to an inch, and the vertical 200 feet to an inch, reduced in publication. The datum is the sea-level according to the best determinations, and both sides of the valley are given side by side. The parts of the banks above low-water are shaded to indicate the strata of different geological periods, but it must be borne in mind that this low-water line does not represent the low-water slope of the winding river, but is drawn from point to point along the general course of the valley, so as to bring the rocks into their proper relative positions. These longitudinal profiles are designated as Diagram 2, in two sheets.

Another sheet, designated as Diagram 3, gives twenty transverse valley sections, on a larger scale than the profiles: three of them on the Minnesota Valley; one on the Mississippi, above the junction with the Minnesota; fourteen of them in the valley between the Minnesota and the Ohio; one at the mouth of the Missouri River, and one at the mouth of the Illinois River. These sections are designed to show the extent of our positive knowledge of the depth of the bed-rock, and will be described in detail in the latter part of this chapter.

We are mainly indebted for the geological data in these profiles and sections to the report of David Dale Owen, October, 1851, on the Geological Survey of Wisconsin, Iowa and Minnesota; to the report on the Geological Survey of Iowa, by Prof. James Hall, Prof. J. D. Whitney and Mr. A. H. Worthen, published in 1858, and the report of Mr. A. H. Worthen, director of the Geological Survey of Illinois, published in 1866.

Method of treating question of depth of bed-rock.—The question of depth of the bed-rock beneath the sand that usually forms the bed of the river will occupy the remainder of this chapter.

In presenting my ideas in regard to it, I have thought the best order in which I could arrange them would be that in which they arose in the progress of the investigation. It was from the first obvious that means and time would not allow of my covering such an extended field by actual borings, and that the most that could be done was to draw such probable inferences as could be done by a study of the rocks visible in the bluffs and by an effort to comprehend the manner in which the valley was formed.

The consideration of the anomaly presented by Lake Pepin lying in the course of the river, and said to have a depth of sixty feet near its lower end, was the beginning of this effort. If the valley in this portion had once been all of this depth, and since filled in, then the bed-rock could not be less than sixty feet

below the water surface. Explanations of the cause of this lake had been attempted by Long and by Featherstonhaugh, which did not seem to me satisfactory.

Explanation of the cause of Lake Pepin and similar lakes.—The results of the levelings on the Minnesota and Mississippi Rivers made by me showed that just below the entrance of any considerable affluent there was an accumulation of deposit in the main stream brought by the tributary; that over this deposit the slope of the water was greater than the average slope, and that it was shoal and impeded navigation; that just above the affluent the slope was less than the average, and the water deeper. So far, this was in accordance with conditions which generally exist in rivers, and might be so even where the main stream was gradually wearing away and deepening its bed.

But a marked peculiarity was exhibited at the junction of the Minnesota and Mississippi Rivers. Regarding the Mississippi as the affluent (which we might do from the comparative sizes of the two valleys), the rule here would be as it is elsewhere, steep slope and shoal water below the affluent and almost no slope and very deep water above. In this instance the effect is felt above for at least thirty miles. On the other hand, taking the Mississippi as the main stream (as the volume of its water has always caused it to be regarded), then we have the anomaly of the main stream filling up the valley and damming back the affluent so that the latter brings no coarse material whatever into the main valley or has any part in forming the shoal below the junction of the two streams.

I called attention to this in my report published in 1867, and again made the anomalous condition a feature in my report on the Minnesota River,* where diagrams were given of the streams and valleys at the junction, and of the Minnesota at its source in Lakes Big-Stone and Travers, which I here repeat as Diagrams C and C′. The Minnesota Valley maintains these widths and depths throughout its course. I have also prepared a small contour map of the sources of the Minnesota and Mississippi Rivers, to show the important position occupied in this system of slopes by the Minnesota Rivers, and give it as Diagram G.

In the report on the Minnesota, above referred to, I showed that the valley of the Minnesota River had, in the period subsequent to the glacial-drift epoch, been occupied by a much larger river, which had formed the outlet of a great lake, embracing the lake Winnipeg and receiving the drainage of its basin, and extending as far south as the present Lake Traverse at the sources of the Minnesota River.† This ancient river, if its volume were as great in proportion to area as that of the

* Annual Report Chief of Engineers, 1875, Part I, page 387.
† Ibid, 1868, pp. 307–314.

Mississippi above the Falls of St. Anthony, probably equaled Niagara in volume, and would have been sufficient to prevent the formation of such excessive accumulation of *débris* in its course, such as the Mississippi is now making below the Minnesota River, although it is probable that the material brought into it from the near proximity of the Falls of St. Anthony would have had the usual effect of somewhat increasing the slope and shoalness just below its junction, and decreasing the slope and increasing the average depth just above.

Accepting, then, the conclusion which I have elsewhere made reasonable, that the drainage of the Winnipeg basin was formerly along the Minnesota and Mississippi below the junction, then when the flow of water from that great northern basin ceased there would no longer be the volume of water necessary to remove the deposits brought by the affluents into a channel of too great capacity for the requirements of the new conditions.

In building the railroad bridge across the mouth of the Minnesota, Mr. Shepard, the engineer, made borings to ascertain the character of the foundations. A rod was forced down about sixty feet, at which distance a stratum was reached so yielding that the rod's weight would be barely supported. He did not endeavor to probe further, for just before reaching this soft layer he passed through a harder one of sufficient thickness and resistance to support his structure. This bridge is a work of minor character. This shows that the deposit in the old valley exceeds sixty feet at this point. The Minnesota being a muddy stream, its fine silt has much filled the lake which the Mississippi *débris* at its mouth caused.

The *débris* and material brought over and from the Falls of St. Anthony has been carried downward by the water, gradually accumulating and filling the valley as it advanced. One should here stop and consider the manner in which river deposits are made. The finest clay is so easily mingled with the water, that the slightest disturbances in the fluid as it moves along even with gentle currents, is sufficient to keep it from settling down until still water is reached. The amount of this on the Upper Mississippi is comparatively very small. Such materials as can be moved only by the swiftest currents are rolled over along the bottom, gradually diminishing in size by friction, and furnishing smaller particles susceptible of being thus moved by feebler currents. The resulting material is pebbles, gravel and sand, the fine material such as clay and vegetable matter, being all washed out.

When deposits of gravel or sand are made of materials moved along the bottom, it takes place as soon as the current slackens, as it must do on reaching a place having a larger sectional area. The deposit is sudden, and the material is all taken up in diminishing the section, until the velocity of transportation is

restored; then deposition continues immediately in front of the last deposit. Such deposition, therefore, does not extend laterally from the course of the current into any contiguous dead water, as depositions from water holding a clayey or vegetable matter would.

Thus in the valley of the Mississippi, the lakes alongside the river's course are deeper than the river, which has continued to raise its bed by deposits of sand after the lakes were cut off from its current.

From the Falls of St. Anthony down to the St. Croix River the Mississippi Valley receives no considerable tributary. The St. Croix comes from a region of trap rock now furnishing little or no large and heavy sedimentary matter. The result has been that the Mississippi deposit of sand and gravel has been thrown across its mouth, holding back its water and forming the St. Croix Lake. At low water, while the depth of the Mississippi at the junction is two and one-half feet, the depth in Lake St. Croix is twenty-five feet. It is not probable that twenty-five feet depth represents the amount of filling of the ancient valley at this point, because the lake itself must have been somewhat shoaled with fine deposits of clay and vegetable matter.

The next considerable tributary to the Mississippi Valley is the Chippewa River. This, entering at right angles with a steep river slope and a probable high-water volume of at least 40,000 cubic feet per second, comes from a region inexhaustibly supplied with siliceous sand and gravel containing a considerable of the heavy magnetic sand, whose oxidation often cements the other sand deposits.* It brings quantities of these materials which, spread out below, give a very steep slope to the Mississippi River, and very bad shoals for navigation.

Lying just above this deposit is Lake Pepin, which it completely accounts for. The reason this lake has not been filled up by the Mississippi above is that the supply of sand from the Chippewa is so great as to raise the level more rapidly than the filling above can keep pace with. The Chippewa from the left bank pushes its sand-bar out, so as to confine the outlet of the lake to the opposite shore. There is an observable relation between the condition of the lake and the deposits of the Chippewa. The deepening of the waters by the deposit of Chippewa sands is felt at low water sometimes as far up as the mouth of the St. Croix, when floods in the Chippewa make these deposits large, and on the other hand, in times of droughts the waters of the lake cut the outlet deeper, and lower its level, so that the shoal water is moved down the river two to three miles below the St. Croix.

* "The analysis of the soil on this part of the Chippewa River (the Yellow Banks) gives ninety-three per cent of insoluble matter, which is chiefly white sand, with only two per cent of organic matter, less than four per cent of soluble saline matter, consisting chiefly of oxide of iron and alumina with only a trace of calcareous earth."—Owen's Report, p. 56.

If we follow the Mississippi down we find similar conditions produced by the Wisconsin River as by the Chippewa; that is, a great increase of the slope and shoaling of the river below the junction, with gentler slopes, deep water, and lake-like aspect above. There would probably have been a large lake here, if the affluents above had not silted it up.

Another instance is afforded by the damming-back effect of the Mississippi deposit at the mouth of the Illinois River, making it at low water almost like a lake up to La Salle.

Lake Pepin must therefore be regarded as due to the deposit by the Chippewa of heavy coarse sediment into the valley of an ancient and larger river. This view may be strengthened further by the following considerations: It lies immediately in the course of the main valley above an important tributary. In this respect it agrees with Lac-qui-parle, on the Minnesota, just above the Lac-qui-parle River; with another lake on the same valley just above Yellow Earth River; with Big Stone Lake in the same valley, just above Whetstone River; with Lake Traverse, which is formed by deposits from a stream at each end, and thus empties sometimes in both directions. It agrees in this relation with the lakes on the Qu'Appelle, which all lie just above a considerable tributary, and with like lakes on the Upper Fox of Lake Winnebago. This constant relation seems unmistakably one of cause and effect.

Valley now filling up.—From what has been stated above, it is clear that the river valley in the part we have considered is not now being deepened by erosions, but, on the contrary, is filling up, and it appears to be doing so all along its lower course except at the rapids.

Recent drainage of Lake Winnipeg southward.—As I have stated in previous reports, I regard the ancient river draining the Winnipeg southward by the Minnesota and Mississippi Valley as existing subsequent to the glacial deposits. This is based upon the fact that the river's course is cut through those deposits, as shown by the banks in many places from Lake Traverse, in Minnesota, to Warsaw, in Illinois, and that the ancient bed of Lake Winnipeg is free from glacial deposits, and exhibits only the silt-deposit since made by the ancient lake itself.

Valley formed since the glaciers began to retire.—It also seems most probable that the ancient valley itself, as a whole, was formed in the region of glacial deposits, partly during the period this great field of ice was receding, and partly since it left the ancient Mississippi basin, for the following reasons: When this ice-period was on the increase, its southern margin must have been gradually advancing in this region, crushing down and planing off the ridges and filling the ravines and water-courses with the *débris* not only of the neighboring rocks, but with

the great mass of hard rocks and other material brought from regions far to the north. There seems a probability that much of the present Upper Mississippi basin had previously been for long ages exposed only to erosions of streams and of the atmosphere, so that it was probably much cut up and fissured, as we see in regions farther west, where no glacial action has occurred. It must have been an easy matter then for the glacier to have thoroughly filled up all the valleys and ravines, leaving the surface everywhere of the well-known rounded hill and basin forms of the drift regions. Wherever the glacial scratchings are preserved, their uniform directions indicate a massive movement to the southwest quite independent of all influence of underlying inequalities. The water which flowed from them would seek the first lowest line and excavate its course without regard to the nature of the older stratified rocks buried beneath the glacial deposits, and such seems to have been the case, for the valley takes a great variety of courses, running about northeast at St. Paul, due west at Rock Island, and its directions fill every azimuth in different parts from northeast around by south to west. To the old stratified rocks its course seems to have no relation, now cutting across an anticlinal, then following the strike in one direction and again in the opposite one.

How the valley was formed.—At St. Paul, on the Mississippi, and in the Minnesota above, are the banks of an ancient water-course when at such higher level than now that the river-bed was the magnesian limestone rock, the same as that of the Mississippi, just above the Falls of St. Anthony. The existing channel of the ancient valley has probably been formed by a cataract in the great river, similar to that at St. Anthony. This view is sustained by the high islands of rock in the valley of the Minnesota, being remains of strata once continuous across it. These high islands also exist below in the Mississippi, such as Barn Bluff, at the head of Lake Pepin, and the Trempeleau hills. Some of these detached bluffs may have been formed by bends approaching each other by erosions gradually forming a neck and cutting it off. One such, nearly completed, is seen in the Dalles of the Chippewa River. The period which must have elapsed in doing this work was long, but it is probable that the volume of water, during the melting of the glaciers north of it, was greatly in excess over that of the present drainage of the Winnipeg basin. The period may have been somewhat shortened by the new water-course regaining in places some ancient one, filled only with glacial *débris*.

If we look at the valley shown on the map from Lake Traverse to Rock Island, we see that it gradually widens and contracts along its course, but, as a whole, widens as we descend. It widens where the rocks on the banks are soft, and narrows where they are harder and capable of resisting atmospheric ero-

sion, as they are near Dubuque. This is in accordance with usually received ideas, that where the stream is confined by hard banks its increased velocity, due to such contractions, may have caused the streams to abrade deeper. It is improbable that the ancient river, where it cut its way either as a cataract or in any other manner of river erosion, made the valley as wide as we now see it. It most probably underwent subsequent widening from the impinging of the currents against the foot of the high banks, thus removing the *débris* falling from the cliffs above, as well as scouring away the unbroken strata against which it washed. Even now, although the great river has disappeared, we see that the valley is still widening in some places where the river flows at the foot of the high bluffs, although, in the great majority of cases, the atmospheric erosions have covered the steep, rocky scarps with detritus, which, clothed with vegetation, preserves them from the influence of the air. Where the river now impinges against the banks composed of soft strata, we sometimes see its effect in the fresh-cut appearance of the cliff, and are led to give greater weight to similar operations in the past, when like forces were probably more intense.

I have selected one (Diagram D) such cliff in the wide part of the valley below La Crosse, which part indicates much widening since the first cutting out of the river's course. It is apparent that no stream of water could have cut down from C to AB while the opening D was available. But if we allow that cataract on the right of the diagram represents the conditions when the stream began to flow which cut the valley, then its present course is natural, the subsequent widening bringing it to the state we see on the left of the diagram.

Geologists of high character have estimated the age of the gorge at Niagara Falls on the present rates of recession, and, though the result is uncertain, it indicates the origin to be in recent geological times, although antedating the historical era. In a similar way the time required by the Mississippi to cut the gorge from Fort Snelling to the Falls of St. Anthony has been calculated by Professor N. H. Winchell,* on data that makes it vary from 6,000 to 12,000 years, by assuming that the forces in producing this result have remained uniform during this period.

That any date in geological time, capable of being expressed in definite numbers of years, can be deduced from existing observations, seems highly improbable; but whenever a condition is observed which may be referred properly to the causes now at work, whether of greater intensity or less, it is reasonable to regard the work done as of recent geological origin. We cannot neglect this uncertain method of drawing inferences, since it is the best we have, and we should endeavor, by continued inves-

* Report Geological Survey Minnesota, 1876.

tigation, to make more definite this method of finding the unknown factor, time.

Since the Falls of St. Anthony were at the junction of Minnehaha Creek, they have receded six and a quarter miles. The Minnehaha Falls, since that time, have receded three-fifths of a mile. Both streams have cut into the same formation, starting with the same height of fall. These relative rates have been as about 1 to 10. The proportion of the volumes of the two streams, judging by their present drainage areas, is about as 72 square miles is to 21,600 square miles, or about as 1 to 300. That is to say, the recession of the Minnehaha Falls has been thirty times faster than it would have been if proportioned to the volume. This may be accounted for by the greater atmospheric influence of the smaller falls, which, examination shows, keeps ahead of the effect of the water, forming a cave under the fall by the dropping down of material which the water then washes away. At the greater falls the volume of water almost constantly protects the rocks from the action of the atmosphere. Hence we must give, as said before, a very considerable influence to the operations of the atmosphere in aiding the erosions of small streams, and in demolishing cliffs where the water can remove the *débris.*

I attribute a more recent origin of the gorge of the Mississippi from Fort Snelling to the Falls of St. Anthony than to that of the Minnesota above the junction. The general map indicates that the same force which formed the valley below the junction formed that of the Minnesota above.

The hypothesis which I have heretofore advanced and endeavored to sustain, that the loss of the Winnepeg outlet along the Minnesota was due to a change of the continental slopes by a northeasterly depression, will explain this more recent origin of the St. Anthony Falls gorge. This supposed change of slope might have caused a change of outlet of the lakes about the present source of the Mississippi, so that the waters flowed out on the northeast and, falling into a depression leading southward, made this upper part of the Mississippi. When we note the great extent of the eroded valley of the Minnesota, and also the fact that all the smaller streams, like the St. Croix, Chippewa, Black and Wisconsin, have cut through the sedimentary rock down to the granitic or trap rocks, it seems improbable that the Mississippi above Fort Snelling, with its greater power, should not have accomplished as much if it had been as long at work.

Regarding the Mississippi Valley as originating as a whole by the action of a stream since the glacial ice occupied its basin, I would note that as far down as the island of Rock Island there is no decided indication of other than successive changes attending such action, and the gradual filling up of the valley

by tributary sediment after the great volume of water from the Winnipeg basin had disappeared.

Anomalies of Rock Island Rapids and Des Moines Rapids.—At Rock Island the river has left the ancient valley, which just below Rock River seems to be lost. We might have supposed that it ended here but for finding it again below Muscatine and continuous down to the Des Moines Rapids, where it is lost again. Just below, however, we find it again, and it then is continuous until it widens out into the broad expanse below the junction of the Ohio, although the river again leaves the main valley, without sufficient apparent cause, at Fountain Bluff and at the Grand Chain.

We had not time to study out where the course of the ancient valley was between Rock Island and Muscatine, but at the Des Moines Rapids we were more fortunate.

The following description of this vicinity and Diagram E will present the points that appear deserving of consideration.

The river, as it passes the town of Madison on its right bank, which is there 150 feet high, washes against a bluff composed of clay and sand arranged in a manner resembling "the ebb and flow structure." Mr. Worthen gives a good description of this formation in the Iowa Geological Report, volume i, part 1, page 187. This kind of bluff is seen only on the right bank, and extends continuously a distance of about twenty-five miles from the mouth of Skunk River down to the point D (see Diagram E), where it joins the Keokuk limestone rock just back of Montrose.

In descending the river from Madison, the river gradually recedes from this bluff, and a few miles above D the bluff is three miles from the river. A large portion of the intervening space is occupied by a sand terrace, varying from twenty to fifty feet in height above the high water; the other portion is bottom land, subject to overflow.

The river, before reaching Montrose, has a width within its banks at ordinary stages of about half a mile, and the depth of water in the pools at low stage is from fifteen to twenty feet, the bed being of sand, with no rock in place; nor is there any rock in the right-bank bluffs till just below Montrose, where it begins also in the river-bed. On the left bank or Illinois side the bluffs are of rock, the same as at the rapids, where they have been cut through by the river. This cut begins at Montrose, where the river makes a turn at a right angle to the eastward, but the depth at low water is only two to three feet, and the width at ordinary stages has widened to one mile. On both sides of the rapids the rock bluffs rise almost immediately from the water. The river on the rapids continues easterly about two miles, then turns southward and maintains this direction until all the rapids are passed and for a mile beyond; then

turns southwest until the mouth of the Des Moines River is passed, and then turns southward again.

The rock disappears in the bed on passing Keokuk; the water then deepens, flowing on a sandy bed, and resumes its width of about half a mile between its ordinary banks. On the rapids there are no considerable or permanent islands, but as you go above or below, you find them as soon as the rock-bed is left.

At Warsaw, three miles below the foot of the rapids, the Carboniferous rocks show in the bluffs, and so does the unmodified glacial drift, covered with the loess. (See Diagram F.)

The Mississippi Valley at Warsaw is about eight miles wide; part of it a sand terrace, but most of it subject to overflow.

Proceeding up the Des Moines from the mouth, we leave the limestone strata at the point H (Diagram E), and do not meet with it again, either in the river bed or bluffs, till we reach the point C, where we find it in both places, and thence all along up this valley.

In this distance between H and C the bluffs are only on the left bank or north side, and the material appears similar to that at Madison or to the loess at Warsaw, shown in Diagram F. If we examine the valley of Sugar Creek, we find the bluffs cut down as low as on the Des Moines between H and C, and all of similar material, clay and sand, but no rock in place. Nor could we find on any of the branches between ABC and DEH any rock in place or learn of any. Within these limiting lines those who have dug wells for water find it without reaching rock.

At the place marked K on the sand terrace a well fifty feet deep encountered no rock, although this was as far down as the level of low water in the river.

The width of the main valley above Fort Madison is nearly the same as below Keokuk, and if we prolong the line of bluff between these two places, it will include a space between them where there is no known rock *in situ*, and which it appears reasonable represents the ancient channel, since filled up.

The loess formation.—This name has been given in this country to a fine material deposited over all the other formations, including the glacial deposits near the river, but not upon the river sand-and-gravel terraces, which are therefore the more recent. It has a thickness of many feet in places. It is generally regarded as having been deposited in quiet water. In many places it is nearly uniform in thickness, conforming with the previous irregularities of the surface, as snow lies where it has not drifted. This would be brought about by a silt laden fresh-water current spreading out over one more dense and quiet, through which the fine silt dropped. Such conditions would exist in salt water, and the silt would prevent the exist-

ence of many kinds of marine life, and would contain the animal remains brought from the fresh-water streams.

The margins of the loess deposits are not well defined, and do not appear to have been investigated as they should be. The deposit is well shown near Rock Island, but does not appear as high up as Dubuque (so far as I know). It extends up the Missouri as far as Sioux City, and the Missouri River made immense deposits into the body of water in which the loess was laid down. From the absence of marine fossils, this body of water has been regarded as fresh and without connection with the Gulf of Mexico except through an outlet. Judging by what I know of the deposits, I should think it did not connect with our present Great Lakes, and that a tongue of land or promontory separated the arms extending up the Mississippi and Missouri Rivers.

The streams which brought this fine loess material which has been so spread out must have brought down heavier material along the bottom that fell as soon as it reached the enlarged section, just as rivers make their deposits of heavy material now on reaching their natural receptacles. A most interesting case in point is in the deposits made in the Great Salt Lake in quaternary times, where its terraces show a level nearly a thousand feet above its present surface. The streams, like the Weber, built out the terrace at their point of discharge in the fan shape of a river-bar up to this terrace level near the ancient shore, and extending back in the river valley, which must then have appeared as a fiord. Although the ancient Weber River deposit diminished in amount as it extended into the ancient lake, yet it terminated quite abruptly. I think, then, there is good reason to regard the bluff-deposits at Fort Madison and vicinity, on the west side of the valley, as belonging to the loess period, and not to glacial times. These deposits are where streams would bring them from the northwest, while the glacial deposits seem to have come from the northeast. This filling up of the ancient valley of Keokuk and Madison, and also in the neighborhood of Rock Island, is where the mouths of considerable rivers probably were during the existence of the large body of water in which the deposition of the loess was made.

Formation of rapids since the loess.—When the body of water of the loess period disappeared and the emergence of the land again took place, the Mississippi did not regain its ancient channel, but cut the new one now occupied. These rapids cannot be accounted for by any special hardness of the rocks, but their resistance is increased because of the dip of the strata being nearly that of the river-slope. When the river was at a higher level and made the sweeping bend above Montrose so as to wash the loess bluffs, but little more erosion would have

been required there to have carried the river back again to its ancient channel during some extraordinary flood, and yet it might have been that the new channel would even after this remain the permanent one for ordinary stages.

Such an explanation as this may be applicable to the cases at Fountain Bluff and at the Grand Chain on the Mississippi just above the mouth of the Ohio, and to the almost incomprehensible changes of course in the Lower Ohio itself, shown on the general map.

Another interesting supposition may be made that the Mississippi in the last terrace period might have succeeded in washing down the bluffs, separating it near Burlington from the Crooked Creek flowing into the Illinois. (See Diagram 1, sheet 4.) The new channel would have double the descent to the mouth of the Illinois of the existing one, and we might have gained a new course for the river, leaving a larger ancient channel occupied by a smaller stream, and there would have been set at work a new cause to modify all the valley of the Illinois River and all the Mississippi above.

Summary of principal points presented.—I will summarize the principal facts that seem to be made out along the course of the Minnesota and Mississippi:

1. That the Minnesota Valley and the Mississippi Valley above the Ohio have been, as a rule, formed since the deposition of the glacial drift, for this exists in unmodified and modified forms in the banks of the river; and that the Winnipeg basin drained out southward along it.

2. That the loess deposits, extending up to the neighborhood of Savannah, are later than the last glacial drift.

3. That channels like those at the Des Moines Rapids and river terraces in that vicinity are more recent than the loess.

Explanatory hypotheses.—I have advanced this hypothesis of southern elevation and northern depression several times before and illustrated its effect on the Minnesota and on the Wisconsin Rivers, and in the first instance considered what the results would be in contiguous regions, and how far facts seemed to correspond, and it is unnecessary to repeat them here.

The hypothesis appears to be in accordance with a number of very important facts, and is consistent with observations as to southern elevation and northern depression now going on. It explains, by one widely exerted influence, many effects which, on the grounds of glacial action alone, requires many special glaciers, and it will answer as an explanation of the coming on and disappearance of the loess body of water, and for the change in the drainage of Lake Winnipeg.

I think this change of relative elevation south and depression north has been probably reversed at some periods, and repeated. This is important, for, if we can show that any movement of

the earth's crust is a recurrent phenomenon, it may help us to trace out its cause.

Approximate practical conclusions.—The only practical conclusion which can be drawn from the preceding discussion seems to be that the origin of the excavation of the valley is comparatively modern, and that it was from the operation of forces producing probably uniform results, and in a way that we have some approximate comprehension of it in general, from our knowledge of special localities.

Note.—Descriptions of the best known sections of the valley follow in the report.

ART. LI.—*On some points in Lithology;* by JAMES D. DANA.

[Continued from page 343.]

4. *Containing Quartz or not.*—Since quartz is the most universal of the materials of rocks, its presence is least entitled to be made a basis for distinctions among them. In sedimentary deposits, the original of many of the crystalline kinds, it is a very common ingredient owing to their mode of origin, and its more or less abundance is a matter of no great geological importance. Sufficient reasons exist, therefore, for the course pursued by recent writers on lithology in making the presence or not of quartz even in crystalline rocks a basis only for a subdivision under a *kind* of rock. Thus there is under dioryte, *quartz-dioryte;* under trachyte, *quartz-trachyte;* under felsyte, *quartz-felsyte;* and so in other cases.

Syenyte is defined by such authors as consisting chiefly of orthoclase and hornblende. Now a rock made prominently of these minerals often contains also quartz; and the name for the quartz-bearing kind, which a system of lithology using the above-cited terms would seem to require, would be *quartz-syenyte.* To call it "hornblende-granite," as is often done, is at variance with the system which uses the word *quartz* as an affix in other cases.

This term "hornblende-granite" is at variance also with the fundamental idea and nature of granite. Granite is eminently a potash-bearing rock. The feldspar is a potash-bearing species; and the mica, whether muscovite or biotite, yields on analysis little less potash than the feldspar, the amount being eight to twelve per cent. These two micas are both present in most granite, gneiss and mica schist: and they are so near akin that they sometimes occur combined in a single crystal—the presence of a little iron in the original material having apparently determined the formation of the latter where it occurs. On the contrary the hornblende of such rocks contains usually

less than one per cent of alkalies, and rarely in any kinds over five per cent. Looking to chemical and mineralogical constitution—the true criterion as to identity among rocks—the strongly drawn line is between the mica-bearing series and the hornblende-bearing series. Granite belongs to a *mica* and *potash-feldspar series;* and syenyte, whether quartzless or quartz-bearing, to a *hornblende* and *potash-feldspar series.*

Moreover, the original syenyte, from Syene, Egypt (to which the name "syenites" was applied by Pliny and other ancient writers) is a quartz-bearing "syenites." The larger part of the syenyte of all Archæan regions is quartz-bearing. The quartzless kind is seldom met with in Eastern North America, or, as far as explored, in the Rocky Mountain region. There are hornblende granites; but these are granites which contain hornblenbe *in addition to* the mica and other ingredients.

Transitions are common between granite, hornblende-granite and quartz-bearing syenyte; but they are so also between these and quartzless syenyte, between syenyte-gneiss and ordinary gneiss, between hornblende schist and mica schist, and between these and other rocks. They are throughout lithology a source of difficulty in characterizing kinds of rocks, as already stated. But they do not set aside the fact that the division between the mica and potash-feldspar series and the hornblende and potash-feldspar series is the most reasonable on mineralogical and chemical grounds.

5. *Containing* "*Plagioclase.*"—The fact that the composition of the triclinic feldspars between the extreme species albite, a sodium-aluminum tersilicate, and anorthite, a calcium-aluminum bisilicate, may be explained by supposing them combinations of these species through isomorphous substitutions of the tersilicate and bisilicate (the amount of sodium present determining the amount of tersilicate in the combination, and the amount of calcium that of bisilicate) was immediately followed by the assumption that these two silicates combined *indefinitely*, and, therefore, that all the triclinic feldspars were essentially one species, and for this reputed species the name *plagioclase* has been used. Some ground for the assumption was found in the analyses of the feldspars; but how much was uncertain, because, in several cases, *mechanical* mixtures of one species with another had been ascertained to exist in crystals. Now that Des Cloizeaux has proved, by optical investigations, that several of the species of triclinic feldspars are really species, that is, that the combinations of the two silicates, the tersilicate and bisilicate, are based on *definite* ratios, as in combinations in other departments of chemistry, and that there are not indefinite blendings, the term "plagioclase" has become merely a synonym for "triclinic feldspar."

The consequences to lithology of this introduction of the term "plagioclase" were unfortunately great. It was made a sufficient definition of a rock to say that it consisted of "*plagioclase* and hornblende," "*plagioclase* and augite," and so on; and this is now common in recent memoirs on rocks. It was a convenient idea; for an examination with the microscope is made in a hundreth part of the time required for a chemical analysis.

Now this word "plagioclase" covers compounds varying in the silica afforded by analyses from 43 to 69 per cent; and in the alkali from all lime (20 per cent) to all soda (12 per cent.) Anorthite, the lime feldspar, is not oligoclase, even if to the two a common name be applied; they still differ 20 per cent in silica (which is one-fifth the mass), and also in the alkali present. Expressions like "consisting of plagioclase and hornblende," as in the definition of dioryte, have consequently an immensely wide signification; for the word dioryte is made to cover oligioclase-dioryte, labradorite-dioryte, and anorthite-dioryte.

This confounding of things thus unlike may be called simplifying the science of lithology; but it is a confounding of important distinctions in the view of those who are interested in a definite knowledge of rocks, and in the important geological questions connected with their constitution. Some lithologists recognize the bearings of such questions, and use the qualified terms for the kinds of dioryte above cited. But the most recent turn is in the other direction. Rosenbusch's learned work, the latest, says that the rocks of the "family" of diabase consist of "plagioclase and augite," and that the feldspars, oligoclase, labradorite and anorthite have been observed in them. Dioryte is defined as a "family" of older rocks consisting essentially of "plagioclase and hornblende." Had the different *kinds* of rocks embraced in these families been separately stated and described, the account might have been satisfactory. But, under both diabase and dioryte, the term "plagioclase" is used as if sufficiently defined in itself, and under dioryte it is given with its aggregate signification alone, no mention being made of the particular feldspar the dioryte of different localities contains.*

If a dioryte happens to be porphyritic, it is at once put into the grand division of dioryte-porphyry, when the only distinction may be that the feldspar is in defined crystals, the chemical and mineralogical constitution being identical. But if the feldspar of one dioryte contains twenty per cent of silica more than another and no soda at all, it is still all dioryte.

* It should be here acknowledged that Rosenbusch's very valuable work bears the title "Mikroskopische Physiographie der massigen Gesteine" so that it does not claim to cover the subject of the chemical or mineralogical constitution of rocks.

In geology, it is essential to a thorough study of the questions it has before it that the kinds of feldspars should not be massed under a common name; and that in every case the investigation should be considered unfinished until not merely the amount of silica in the rock is accurately ascertained, but also the particular species of feldspar is correctly and fully determined, however great the labor required to reach a conclusion. The use of the term *plagioclase* in such a case is an acknowledgment of incomplete work, and should be so treated.

But the objection to the use of the term "plagioclase" is still stronger than has been stated. It now includes not only the soda-lime feldspars from anorthite to albite inclusive, but also part of *potash*-feldspar. The establishment, on an unquestionable basis, of Breithaupt's *microcline* by Des Cloizeaux, and his further observations that this triclinic potash-feldspar is a very common mineral, much of what was supposed to be orthoclase belonging to it, has extended the range of "plagioclase," until it is now almost an equivalent of the general term feldspar, so that "*plagioclase* and hornblende" has, as to chemical constitution, the same signification now with *feldspar* and hornblende.

6. *Rocks consisting of a triclinic feldspar and mica.*—The term dioryte, formerly defined as a rock consisting of oligoclase or albite and hornblende, has been introduced into the name of a series of rocks containing no hornblende, but mica instead. Thus: "*mica-dioryte*" is defined as a "plagioclase-mica rock" in which mica is substituted partly or wholly for hornblende, and it is called mica-dioryte whichever of the triclinic feldspars be present, even if anorthite. This change in the use of the name dioryte so as to include a rock containing no hornblende, makes "plagioclase" the essential constituent, and places mica and hornblende in a subordinate position, as the heads only of subdivisions.

The remarks made respecting syenyte apply equally here: and also those respecting "plagioclase." A mica-dioryte is, like granite, eminently an alkali-yielding rock, the mica (biotite) affording usually ten per cent of potash; and as granites often contain oligoclase as well as orthoclase, the amount of potash and soda in a "mica-dioryte" and a granite may not be very widely different. Dioryte, on the contrary, is prominently a hornblende rock.

Looking to the mineralogical and chemical constitution of the rocks, we are naturally led to recognize along side of a mica and *potash-feldspar* series, which is headed by granite, also a mica and *soda-lime feldspar* series, and to include in the latter the so-called mica-diorytes.

7. *Hornblendic or Augitic.*—Hornblendic and augitic rocks stand apart as a general thing in all systems of lithology. Yet

the minerals are essentially identical in chemical composition, and related in crystallization, though different in their occurring crystalline forms and in the angle of the cleavage prism. The identity in composition is so close that chemical analysis is not able to distinguish them. Hence the related eruptive rocks of the hornblendic and augitic series (or those containing the same species of feldspar in like proportions) must have originated in material of essentially the same chemical composition. The relation between the two minerals is thus far closer than between the triclinic species of feldspars.

Nevertheless, too much importance is not given them when each is made distinctive of an independent series of rocks; for the very wide extent to which augitic rocks retain unvaryingly their augitic characters—such rocks constituting full two-thirds of the earth's eruptive masses—shows that the special conditions producing augite, instead of hornblende, whatever they are, have often acted on a vast scale in the earth's history. And so, also, the very wide distribution of hornblendic rocks, especially among the metamorphic kinds, is evidence of a like comprehensive influence of the conditions needed to make hornblende in place of augite. The geological importance of the distinction is reason enough for recognizing it in lithological systems.

8. *Massive or Schistose.*—Massive structure is often made *prima facie* evidence of igneous origin. Granite, with hardly a questioning thought, has usually been placed solely among eruptive rocks. The igneous origin of dioryte even now is hardly left open to investigation by some lithologists. Serpentine has been in the same category, though at present there are advocates of its metamorphic origin. And so other massive rocks are too likely to be set down as eruptive without a fair investigation. No two rocks are put farther apart in some lithological systems than granite and gneiss; and yet, none are more closely related in constitution and all essential characteristics.

The following are reasons for disregarding this distinction of massive or schistose in classifying rocks, and for allowing a massive structure little weight in deciding the question as to eruptive or metamorphic origin.

(1.) *Massive rocks may be both metamorphic and eruptive.* Granite, syenyte, with dioryte and other hornblendic rocks, are examples of massive rocks that are of both modes of origin. Many localities where kinds of these rocks occur metamorphic have been described. I will mention two or three from the many I have observed in New England. (*a*) Ten miles east of New Haven, Connecticut, in a railroad cut at Stoney Creek, a bed of granite, having a small northward dip, changes gradually to gneiss, and then to gneiss with some very micaceous mica

schist, so that within thirty yards from east to west these three rocks are found constituting the same bed; and the granite is a part of the general gneissic formation of the region. (b) The labradorite-dioryte two miles west of New Haven graduates rather abruptly above and below, and also laterally, from a massive rock into a slaty chloritic mica schist, and does this so often and variously, that there is no reason for questioning its metamorphic origin. (c) A hornblende (or actinolite) rock, just northeast of Bernardston, of a massive kind, occurs among thin schistose beds of mica schist and hornblendic schist and is part of a series of metamorphic strata. From a hand specimen either of these rocks would be pronounced eruptive; but observation in the field proves that they are not so.

(2.) *Certain kinds of mineral constituents are almost sure to make a massive metamorphic rock when the process of metamorphism is one attended with much heat.* Hornblende and augite are minerals of this kind. Both are rather fusible, and crystallize readily, so that heat easily obliterates all traces of bedding. This principle alone will account for the fact that the rocks northeast of Bernardston, alluded to above, are massive wherever hornblende is the chief ingredient. It explains also the existence of the massive labradorite-dioryte among the schists west of New Haven. Feldspar also, when alone, or accompanied by quartz without any associated mica (as in felsyte, quartz-felsyte, granulyte), is almost sure, under the circumstances mentioned, to make a rock, with the bedding obliterated, in other words, a massive rock; and only with a low degree of heat in the metamorphism, would any original bedding be retained. And even if hornblende is present, there is the same tendency to massive forms. Serpentine is another species that makes almost necessarily a massive rock, whatever the method of origin, because the mineral has nothing in its structure that favors any other condition.

(3.) *Pressure may be a source of schistosity or foliation, and it may also obliterate bedding.* On the first of these points illustration is not necessary. As to the second, there are many examples in the crystalline limestone region of Western New England, both in Vermont, Massachusetts and Connecticut. At West Rutland, Vermont, as first observed by Prof. Edward Hitchcock, many limestone beds have been cemented by the pressure which gave them their high dip into a bed of great thickness, so that masses as large as a moderate-sized house could be cut out if needed. The component beds are easily distinguished in the southernmost of the three quarries. Moreover, in the middle of the same valley the metamorphism of the limestone stratum was not complete enough to obliterate the fossils—shells, corals and crinoids being distinguishable; so that there could have been

no fusion to produce the coalescence. As this welding of beds is so perfect in the limestone, it is reasonable to believe that a similar cause may have acted in the case of feldspathic, hornblendic and augitic rocks, without even the aid of incipient fusion.

(4.) *The sedimentary beds which have been converted into crystalline rocks were often originally massive.*—This is the condition of most conglomerates, and often of coarse sandstones. In such cases there would be no bedding to obliterate; and the production of a massive rock would be a natural result of the metamorphism, whether the heat attending it were great or small. Part of the metamorphic granite of the world may therefore never have been in a pasty state; and so also part of the metamorphic hornblende rocks; some metamorphic felsyte beds, certainly those that are of conglomerate origin, were originally massive.

There is hence reason enough for neglecting the distinction of massive and schistose in drawing out a system or classification of rocks, and for making the question of origin in the case of either kind, the massive no less than the schistose, a subject for careful investigation.

9. *Metamorphic or Eruptive.*—The question whether a crystalline rock is metamorphic and *in place*, or eruptive, is of the highest geological interest; for it is a question as to origin. At the same time, no subject, if we exclude the part of metamorphism relating to the obviously schistose rocks, is in so unsatisfactory a state. With some authors, as above intimated, the question so far as it relates to *massive* crystalline rock is not an open one. On the other hand, when investigation has taken place, opposite opinions have generally been reached. The remedy of this is to be found in more thorough study from a wider basis of facts.

Were the question in all cases rightly decided, lithology would be able to study and compare the two series, and give greater completeness and higher geological value to the descriptions of rocks. Applying different names to the like rocks in the two series is not necessary, unless there is some strong geological reason in favor of it; for when a rock occurs both metamorphic and eruptive the fact is best exhibited if that rock has but one name. The writer has proposed to distinguish the metamorphic under any *kind* of rock by adding to the name the prefix *meta;* for example, *dioryte* for the eruptive and *metadioryte* for the metamorphic part. But *meta* is here used simply as an abbreviation of the word *metamorphic*, not to indicate a difference of *kind* in the rock.

Conclusions.

The principal points with regard to rocks which have been brought out in this paper, are the following.

1. The necessities of the science of Geology constitute the most prominent motive for distinguishing *kinds* of rocks; and they should determine to a large extent upon what characters distinctions should be based.

2. In determining the rocks to be grouped as one in *kind* under a common name, near identity in the chemical and mineral composition of the chief constituents is the main point to be considered; not near identity in their crystalline forms, for isomorphism presupposes diversity of composition.

3. Distinction of *kind* should be based on difference in chemical and mineral constitution as regards the chief constituents. When such difference exists, rocks are different in *kind*, and need, for the purposes of geology, distinct names. If it does not exist, the distinction is only that of *variety*; unless (as in the case of trachyte and felsyte), the very wide extension of the rock under persistent characters makes a distinction of name important to geology.

4. It follows from the preceding, that differences in texture: as coarse, or fine, or aphanitic; porphyritic, or non-porphyritic; stoney throughout, or having unindividualized portions among the stoney grains; and differences in microscopic inclusions; are no basis for a distinction of *kind* among rocks, but only of *variety*; and that *porphyritic structure* is of hardly more consequence than coarse or fine granular.

5. No marked change in the constituents of the earth's erupted material occurred after the close of the Cretaceous period, or just before the commencement of the Tertiary era; and, hence, no ground exists for the distinction of "older" and "younger" among eruptive rocks. The "younger" eruptive rocks are essentially like the "older" in chemical composition and their chief mineral constituents; and they differ when at all only in texture and some other points of as little importance —qualities that distinguish merely varieties, and which have proceeded from greater prevalence in these later times of subaerial eruptions.

6. Since "plagioclase" is not the name of a mineral species, —several minerals, of widely different compositions being embraced under it—it is a confounding of differences and resemblances to speak of it as a constituent of a rock. And since it now includes, through the defining of the feldspar microcline, a large part of potash feldspar, which had been supposed to be orthoclase, it has become almost synonymous with the term feldspar. The "simplicity" its adoption has been

supposed to give to lithological system would be greater if "feldspar" were substituted, and with its present range of constitution, the evil would be hardly less.

7. Rocks differing mineralogically, and not chemically, like related hornblendic and augitic rocks (the minerals hornblende and augite being dimorphous), are rightly made distinct rocks, since the difference has depended, to a large extent, on wide-reaching geological operations or conditions, and is, therefore, of great geological signficance.

8. Since quartz is the most widely distributed and therefore the least distinctive of the minerals of rocks, it may rightly be regarded as of subordinate importance in the distinguishing of rocks, and hence not only such names as *dioryte* and *quartz-dioryte*, *trachyte* and *quartz-trachyte*, etc., are acceptable, but also *syenyte* and *quartz-syenyte*.

9. Biotite being closely like muscovite in composition, and not less common than it in granites, gneisses and mica schists, and being, moreover, unlike the mineral hornblende in chemical constitution and formula, the rocks in which biotite is a chief constituent cannot rightly be put in the same group with hornblende rocks; or those in which hornblende is a chief constituent in a group of mica-bearing rocks. Consequently the name "mica-dioryte," for a rock containing no hornblende, and the name "hornblende-granite" for a rock containing no mica but hornblende instead, imply alike false relations.

The discussion suggests the following additional remark:

The incapabilities of the microscope and polariscope have favored the use of the term "plagioclase," and have led some investigators to overlook or slight distinctions in chemical constitution. Lithology is to receive hereafter its greatest advances through chemical analyses; for chemistry alone can clear away the doubts the microscope leaves, and so give that completeness to the Science of Rocks which geology requires for right and comprehensive conclusions.

Moreover the researches made in the laboratory to be of real geological value should be, if possible, supplemented by investigations in the field as to transitions among the rocks, and as to other kinds of relations. This field work has often been well done, but not so by all lithological investigators.

The principles presented lead to the following subdivisions in an arrangement of crystalline rocks, exclusive of the Calcareous and Quartzose kinds. Since leucite is a potash-alumina silicate, like orthoclase and microcline (it affording twenty per cent or more of potash), it is here referred to the same group with the potash feldspars; and nephelite, sodalite and the saussurites being eminently soda-bearing species, they are

included with the soda-lime feldspars (anorthite to albite). This reference for lithological purposes of these minerals is sustained by their resemblance to the feldspars in constituents, and also in the quantivalent ratios between the alkalies, alumina and silica, this ratio being in leucite 1 : 3 : 8, as in andesite, and in sodalite and nephelite 1 : 3 : 4, as in anorthite. The term *potash feldspar*, as used in the headings below, is hence to be understood as covering orthoclase, microcline and leucite; and *soda-lime feldspar*, as including the triclinic feldspars from anorthite to albite, and also nephelite, sodalite and the saussurites.

The arrangement is as follows. In the first series, the rocks graduate into kinds which are all feldspar, and into others that are all mica; and yet the amount of potash present is approximately the same.

I. THE MICA AND POTASH FELDSPAR SERIES: including Granite, Granulyte, Gneiss, Protogine, Mica schist, etc., Felsyte, Trachyte, etc., and the Leucite rock of Wyoming.

II. THE MICA AND SODA-LIME FELDSPAR SERIES: including Kersantite, Kinzigite; and the nephelitic kinds Miascyte, Ditroyte, Phonolyte, etc. (These nephelitic kinds belong almost as well in the preceding series).

III. THE HORNBLENDE AND POTASH FELDSPAR SERIES: including Syenyte (with Quartz-syenyte), Syenyte-gneiss, Hornblende schist, Amphibolyte, Unakyte (this last containing epidote in place of hornblende); and the nephelitic species Zircon-Syenyte, Foyayte.

IV. THE HORNBLENDE AND SODA-LIME FELDSPAR SERIES: including Dioryte (with Propylyte), Andesyte, Labradioryte (or Labrador-dioryte), etc., and the saussurite rock, Euphotide.

V. THE PYROXENE AND POTASH FELDSPAR SERIES: including Amphigenyte.

VI. THE PYROXENE AND SODA-LIME FELDSPAR SERIES: including Augite-Andesyte, Noryte (Hypersthenyte and Gabbro in part), Hypersthenyte (containing true hypersthene), Doleryte (comprising Basalt and Diabase), Nephelinyte, etc.

VII. PYROXENE, GARNET, EPIDOTE AND CHRYSOLITE ROCKS, CONTAINING LITTLE OR NO FELDSPAR: including Pyroxenyte, Lherzolyte, Garnetyte (Garnet rock), Eclogyte, Epidosyte, Chrysolyte or Dunyte (Chrysolite rock), etc.

VIII. HYDROUS MAGNESIAN AND ALUMINOUS ROCKS, CONTAINING LITTLE OR NO FELDSPAR: including Chlorite schist, Talcose schist, Serpentine, Ophiolyte, Pyrophyllite schist, etc.

ART. LII.—*On the Equilibrium of Heterogeneous Substances;* by J. WILLARD GIBBS.* Abstract by the author.

IT is an inference naturally suggested by the general increase of entropy which accompanies the changes occurring in any isolated material system that when the entropy of the system has reached a maximum, the system will be in a state of equilibrium. Although this principle has by no means escaped the attention of physicists, its importance does not appear to have been duly appreciated. Little has been done to develop the principle as a foundation for the general theory of thermodynamic equilibrium.

The principle may be formulated as follows, constituting a criterion of equilibrium:

I. *For the equilibrium of any isolated system it is necessary and sufficient that in all possible variations of the state of the system which do not alter its energy, the variation of its entropy shall either vanish or be negative.*

The following form, which is easily shown to be equivalent to the preceding, is often more convenient in application:

II. *For the equilibrium of any isolated system it is necessary and sufficient that in all possible variations of the state of the system which do not alter its entropy, the variation of its energy shall either vanish or be positive.*

If we denote the energy and entropy of the system by ϵ and η respectively, the criterion of equilibrium may be expressed by either of the formulæ

$$(\delta\eta)_\epsilon \leqq 0, \tag{1}$$

$$(\delta\epsilon)_\eta \geqq 0. \tag{2}$$

Again, if we assume that the temperature of the system is uniform, and denote its absolute temperature by t, and set

$$\psi = \epsilon - t\,\eta, \tag{3}$$

the remaining conditions of equilibrium may be expressed by the formula

$$(\delta\psi)_t \geqq 0, \tag{4}$$

the suffixed letter, as in the preceding cases, indicating that the quantity which it represents is constant. This condition, in connection with that of uniform temperature, may be shown to be equivalent to (1) or (2). The difference of the values of ψ for two different states of the system which have the same temperature represents the work which would be expended in bringing the system from one state to the other by a reversible process and without change of temperature.

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If the system is incapable of thermal changes, like the systems considered in theoretical mechanics, we may regard the entropy as having the constant value zero. Conditions (2) and (4) may then be written

$$\delta\varepsilon \geqq 0, \qquad \delta\psi \geqq 0,$$

and are obviously identical in signification, since in this case $\psi = \varepsilon$.

Conditions (2) and (4), as criteria of equilibrium, may therefore both be regarded as extensions of the criterion employed in ordinary statics to the more general case of a thermodynamic system. In fact, each of the quantities $-\varepsilon$ and $-\psi$ (relating to a system without sensible motion) may be regarded as a kind of force-function for the system,—the former as the force-function *for constant entropy*, (i. e., when only such states of the system are considered as have the same entropy,) and the latter as the force-function *for constant temperature*, (i. e., when only such states of the system are considered as have the same uniform temperature).

In the deduction of the particular conditions of equilibrium for any system, the general formula (4) has an evident advantage over (1) or (2) with respect to the brevity of the processes of reduction, since the limitation of constant temperature applies to every part of the system taken separately, and diminishes by one the number of independent variations in the state of these parts which we have to consider. Moreover, the transition from the systems considered in ordinary mechanics to thermodynamic systems is most naturally made by this formula, since it has always been customary to apply the principles of theoretical mechanics to real systems on the supposition (more or less distinctly conceived and expressed) that the temperature of the system remains constant, the mechanical properties of a thermodynamic system maintained at a constant temperature being such as might be imagined to belong to a purely mechanical system, and admitting of representation by a force-function, as follows directly from the fundamental laws of thermodynamics.

Notwithstanding these considerations, the author has preferred in general to use condition (2) as the criterion of equilibrium, believing that it would be useful to exhibit the conditions of equilibrium of thermodynamic systems in connection with those quantities which are most simple and most general in their definitions, and which appear most important in the general theory of such systems. The slightly different form in which the subject would develop itself, if condition (4) had been chosen as a point of departure instead of (2), is occasionally indicated.

Equilibrium of masses in contact.—The first problem to which the criterion is applied is the determination of the conditions of equilibrium for different masses in contact, when uninfluenced by gravity, electricity, distortion of the solid masses, or capillary tensions. The statement of the result is facilitated by the following definition.

If to any homogeneous mass in a state of hydrostatic stress we suppose an infinitesimal quantity of any substance to be added, the mass remaining homogeneous and its entropy and volume remaining unchanged, the increase of the energy of the mass divided by the quantity of the substance added is the *potential* for that substance in the mass considered.

In addition to equality of temperature and pressure in the masses in contact, it is necessary for equilibrium that the potential for every substance which is an independently variable component of any of the different masses shall have the same value in all of which it is such a component, so far as they are in contact with one another. But if a substance, without being an actual component of a certain mass in the given state of the system, is capable of being absorbed by it, it is sufficient if the value of the potential for that substance in that mass is not less than in any contiguous mass of which the substance is an actual component. We may regard these conditions as sufficient for equilibrium with respect to infinitesimal variations in the composition and thermodynamic state of the different masses in contact. There are certain other conditions which relate to the possible formation of masses entirely different in composition or state from any initially existing. These conditions are best regarded as determining the stability of the system, and will be mentioned under that head.

Anything which restricts the free movement of the component substances, or of the masses as such, may diminish the number of conditions which are necessary for equilibrium.

Equilibrium of osmotic forces.—If we suppose two fluid masses to be separated by a diaphragm which is permeable to some of the component substances and not to others, of the conditions of equilibrium which have just been mentioned, those will still subsist which relate to temperature and the potentials for the substances to which the diaphragm is permeable, but those relating to the potentials for the substances to which the diaphragm is impermeable will no longer be necessary. Whether the pressure must be the same in the two fluids will depend upon the rigidity of the diaphragm. Even when the diaphragm is permeable to all the components without restriction, equality of pressure in the two fluids is not always necessary for equilibrium.

Effect of gravity.—In a system subject to the action of gravity, the potential for each substance, instead of having a uniform value throughout the system, so far as the substance actually occurs as an independently variable component, will decrease uniformly with increasing height, the difference of its values at different levels being equal to the difference of level multiplied by the force of gravity.

Fundamental equations.—Let ε, η, v, t and p denote respectively the energy, entropy, volume, (absolute) temperature, and pressure of a homogeneous mass, which may be either fluid or solid, provided that it is subject only to hydrostatic pressures, and let $m_1, m_2, \ldots m_n$ denote the quantities of its independently variable components, and $\mu_1, \mu_2, \ldots \mu_n$ the potentials for these components. It is easily shown that ε is a function of $\eta, v, m_1, m_2, \ldots m_n$, and that the complete value of $d\varepsilon$ is given by the equation

$$d\varepsilon = t\, d\eta - p\, dv + \mu_1\, dm_1 + \mu_2\, dm_2 \ldots + \mu_n dm_n. \qquad (5)$$

Now if ε is known in terms of $\eta, v, m_1, \ldots m_n$, we can obtain by differentiation $t, p, \mu_1, \ldots \mu_n$ in terms of the same variables. This will make $n+3$ independent known relations between the $2n+5$ variables, $\varepsilon, \eta, v, m_1, m_2, \ldots m_n, t, p, \mu_1, \mu_2, \ldots \mu_n$. These are all that exist, for of these variables, $n+2$ are evidently independent. Now upon these relations depend a very large class of the properties of the compound considered,—we may say in general, all its thermal, mechanical, and chemical properties, so far as *active tendencies* are concerned, in cases in which the form of the mass does not require consideration. A single equation from which all these relations may be deduced may be called a fundamental equation. An equation between $\varepsilon, \eta, v, m_1, m_2, \ldots m_n$ is a fundamental equation. But there are other equations which possess the same property.

If we suppose the quantity ψ to be determined for such a mass as we are considering by equation (3), we may obtain by differentiation and comparison with (5)

$$d\psi = -\eta\, dt - p\, dv + \mu_1\, dm_1 + m_2\, dm_2 \ldots + \mu_n\, dm_n. \qquad (6)$$

If, then, ψ is known as a function of $t, v, m_1, m_2, \ldots m_n$, we can find $\eta, p, \mu_1, \mu_2, \ldots \mu_n$ in terms of the same variables. If we then substitute for ψ in our original equation its value taken from equation (3) we shall have again $n+3$ independent relations between the same $2n+5$ variables as before.

Let

$$\zeta = \varepsilon - t\,\eta + p\,v, \qquad (7)$$

then, by (5),

$$d\zeta = -\eta\, dt + v\, dp + \mu_1\, dm_1 + \mu_2\, dm_2 \ldots + \mu_n\, dm_n. \qquad (8)$$

If, then, ζ is known as a function of t, p, m_1, m_2, ... m_n, we can find η, v, μ_1, μ_2, ... μ_n in terms of the same variables. By eliminating ζ, we may obtain again $n + 3$ independent relations between the same $2n + 5$ variables as at first.*

If we integrate (5), (6) and (8), supposing the quantity of the compound substance considered to vary from zero to any finite value, its nature and state remaining unchanged, we obtain

$$\varepsilon = t\eta - pv + \mu_1 m_1 + \mu_2 m_2 \ldots + \mu_n m_n \tag{9}$$

$$\psi = - pv + \mu_1 m_1 + \mu_2 m_2 \ldots + \mu_n m_n, \tag{10}$$

$$\zeta = \mu_1 m_1 + \mu_2 m_2 \ldots + \mu_n m_n. \tag{11}$$

If we differentiate (9) in the most general manner, and compare the result with (5), we obtain

$$- v\,dp + \eta\,dt + m_1\,d\mu_1 + m_2\,d\mu_2 \ldots + m_n\,d\mu_n = 0, \tag{12}$$

or

$$dp = \frac{\eta}{v}dt + \frac{m_1}{v}d\mu_1 + \frac{m_2}{v}d\mu_2 \ldots + \frac{m_n}{v}d\mu_n = 0. \tag{13}$$

Hence, there is a relation between the $n + 2$ quantities t, p, μ_1, μ_2, ... μ_n, which, if known, will enable us to find in terms of these quantities all the ratios of the $n + 2$ quantities η, v, m_1, m_2, ... m_n. With (9), this will make $n + 3$ independent relations between the same $2n + 5$ variables as at first.

Any equation, therefore, between the quantities

	ε,	η,	v,	m_1,	m_2, ... m_n,
or	ψ,	t,	v,	m_1,	m_2, ... m_n,
or	ζ,	t,	p,	m_1,	m_2, ... m_n,
or		t,	p,	μ_1,	μ_2, ... μ_n,

is a fundamental equation, and any such is entirely equivalent to any other.

Coëxistent phases.—In considering the different homogeneous bodies which can be formed out of any set of component substances, it is convenient to have a term which shall refer solely to the composition and thermodynamic state of any such body without regard to its size or form. The word *phase* has been chosen for this purpose. Such bodies as differ in composition or state are called different phases of the matter considered, all

* The properties of the quantities $-\psi$ and $-\zeta$ regarded as functions of the temperature and volume, and temperature and pressure, respectively, the composition of the body being regarded as invariable, have been discussed by M. Massieu in a memoir entitled "Sur les fonctions caractéristiques des divers fluides et sur la théorie des vapeurs" (*Mém. Savants Étrang.*, t xxii.) A brief sketch of his method in a form slightly different from that ultimately adopted is given in *Comptes Rendus*, t. lxix, (1869) pp. 858 and 1057, and a report on his memoir by M. Bertrand in *Comptes Rendus*, t. lxxi, p. 257. M. Massieu appears to have been the first to solve the problem of representing all the properties of a body of invariable composition which are concerned in reversible processes by means of a single function.

bodies which differ only in size and form being regarded as different examples of the same phase. Phases which can exist together, the dividing surfaces being plain, in an equilibrium which does not depend upon passive resistances to change, are called *coëxistent.*

The number of independent variations of which a system of coëxistent phases is capable is $n+2-r$, where r denotes the number of phases, and n the number of independently variable components in the whole system. For the system of phases is completely specified by the temperature, the pressure, and the n potentials, and between these $n+2$ quantities there are r independent relations (one for each phase), which characterize the system of phases.

When the number of phases exceeds the number of components by unity, the system is capable of a single variation of phase. The pressure and all the potentials may be regarded as functions of the temperature. The determination of these functions depends upon the elimination of the proper quantities from the fundamental equations in p, t, μ_1, μ_2, etc., for the several members of the system. But without a knowledge of these fundamental equations, the values of the differential co-efficients such as $\frac{dp}{dt}$ may be expressed in terms of the entropies and volumes of the different bodies and the quantities of their several components. For this end we have only to eliminate the differentials of the potentials from the different equations of the form (12) relating to the different bodies. In the simplest case, when there is but one component, we obtain the well-known formula

$$\frac{dp}{dt}=\frac{\eta'-\eta''}{v'-v''}=\frac{Q}{t\,(v''-v')},$$

in which v', v'', η', η'', denote the volumes and entropies of a given quantity of the substance in the two phases, and Q the heat which it absorbs in passing from one phase to the other.

It is easily shown that if the temperature of two coëxistent phases of two components is maintained constant, the pressure is in general a maximum or minimum when the composition of the phases is identical. In like manner, if the pressure of the phases is maintained constant, the temperature is in general a maximum or minimum when the composition of the phases is identical. The series of simultaneous values of t and p for which the composition of two coëxistent phases is identical separates those simultaneous values of t and p for which no coëxistent phases are possible from those for which there are two pairs of coëxistent phases.

If the temperature of three coëxistent phases of three compo-

nents is maintained constant, the pressure is in general a maximum or minimum when the composition of one of the phases is such as can be produced by combining the other two. If the pressure is maintained constant, the temperature is in general a maximum or minimum when the same condition in regard to the composition of the phases is fulfilled.

Stability of fluids.—A criterion of the stability of a homogeneous fluid, or of a system of coëxistent fluid phases, is afforded by the expression

$$\varepsilon - t'\eta + p'v - \mu_1'm_1 - \mu_2'm_2 \quad . \quad . \quad . \quad - \mu_n'm_n \tag{14}$$

in which the values of the accented letters are to be determined by the phase or system of phases of which the stability is in question, and the values of the unaccented letters by any other phase of the same components, the possible formation of which is in question. We may call the former constants, and the latter variables. Now if the value of the expression, thus determined, is always positive for any possible values of the variables, the phase or system of phases will be stable with respect to the formation of any new phases of its components. But if the expression is capable of a negative value, the phase or system is at least *practically* unstable. By this is meant that, although, strictly speaking, an infinitely small disturbance or change may not be sufficient to destroy the equilibrium, yet a very small change in the initial state will be sufficient to do so. The presence of a small portion of matter in a phase for which the above expression has a negative value will in general be sufficient to produce this result. In the case of a system of phases, it is of course supposed that their contiguity is such that the formation of the new phase does not involve any transportation of matter through finite distances.

The preceding criterion affords a convenient point of departure in the discussion of the stability of homogeneous fluids. Of the other forms in which the criterion may be expressed, the following is perhaps the most useful.

If the pressure of a fluid is greater than that of any other phase of its independent variable components which has the same temperature and potentials, the fluid is stable with respect to the formation of any other phase of these components; but if its pressure is not as great as that of some such phase, it will be practically unstable.

Stability of fluids with respect to continuous changes of phase.—In considering the changes which may take place in any mass, we have often to distinguish between infinitesimal changes in existing phases, and the formation of entirely new phases. A phase of a fluid may be stable with respect to the former kind of change, and unstable with respect to the latter. In this case, it may be capable of continued existence in virtue of proper-

ties which prevent the commencement of discontinuous changes. But a phase which is unstable with respect to continuous changes is evidently incapable of permanent existence on a large scale except in consequence of passive resistances to change. To obtain the conditions of stability with respect to continuous changes, we have only to limit the application of the variables in (14) to phases adjacent to the given phase. We obtain results of the following nature.

The stability of any phase with respect to continuous changes depends upon the same conditions with respect to the second and higher differential coëfficients of the density of energy regarded as a function of the density of entropy and the densities of the several components, which would make the density of energy a minimum, if the necessary conditions with respect to the first differential coëfficients were fulfilled.

Again, it is necessary and sufficient for the stability with respect to continuous changes of all the phases within any given limits, that within those limits the same conditions should be fulfilled with respect to the second and higher differential coëfficients of the pressure regarded as a function of the temperature and the several potentials, which would make the pressure a minimum, if the necessary conditions with respect to the first differential coëfficients were fulfilled

The equation of the limits of stability with respect to continuous changes may be written

$$\left(\frac{d\mu_n}{d\gamma_n}\right)_{t,\,\mu_1,\,\ldots\,\mu_{n-1}} = 0, \text{ or } \left(\frac{d^2p}{d\mu_n{}^2}\right)_{t,\,\mu_1,\,\ldots\,\mu_{n-1}} = \infty, \quad (15)$$

where γ_n denotes the density of the component specified or $m_n \div v$. It is in general immaterial to what component the suffix $_n$ is regarded as relating.

Critical phases.—The variations of two coëxistent phases are sometimes limited by the vanishing of the difference between them. Phases at which this occurs are called *critical phases.* A critical phase, like any other, is capable of $n+1$ independent variations, n denoting the number of independently variable components. But when subject to the condition of remaining a critical phase, it is capable of only $n-1$ independent variations. There are therefore two independent equations which characterize critical phases. These may be written

$$\left(\frac{d\mu_n}{d\gamma_n}\right)_{t,\,\mu_1,\,\ldots\,\mu_{n-1}} = 0, \left(\frac{d^2\mu_n}{d\gamma_n{}^2}\right)_{t,\,\mu_1,\,\ldots\,\mu_{n-1}} = 0. \quad (16)$$

It will be observed that the first of these equations is identical with the equation of the limit of stability with respect to continuous changes. In fact, stable critical phases are situated at that limit. They are also situated at the limit of stability with

respect to discontinuous changes. These limits are in general distinct, but touch each other at critical phases.

Geometrical illustrations.—In an earlier paper,* the author has described a method of representing the thermodynamic properties of substances of invariable composition by means of surfaces. The volume, entropy, and energy of a constant quantity of the substance are represented by rectangular coördinates. This method corresponds to the first kind of fundamental equation described above. Any other kind of fundamental equation for a substance of invariable composition will suggest an analogous geometrical method. In the present paper, the method in which the coördinates represent temperature, pressure, and the potential, is briefly considered. But when the composition of the body is variable, the fundamental equation cannot be completely represented by any surface or finite number of surfaces. In the case of three components, if we regard the temperature and pressure as constant, as well as the total quantity of matter, the relations between ζ, m_1, m_2, m_3 may be represented by a surface in which the distances of a point from the three sides of a triangular prism represent the quantities m_1, m_2, m_3, and the distance of the point from the base of the prism represents the quantity ζ. In the case of two components, analogous relations may be represented by a plane curve. Such methods are especially useful for illustrating the combinations and separations of the components, and the changes in states of aggregation, which take place when the substances are exposed in varying proportions to the temperature and pressure considered.

Fundamental equations of ideal gases and gas-mixtures.—From the physical properties which we attribute to ideal gases, it is easy to deduce their fundamental equations. The fundamental equation in ε, η, v, and m for an ideal gas is

$$c \log \frac{\varepsilon - \mathrm{E}m}{cm} = \frac{\eta}{m} - \mathrm{H} + a \log \frac{m}{v} : \tag{17}$$

that in ψ, t, v, and m is

$$\psi = \mathrm{E}m + mt\left(c - \mathrm{H} - c \log t + a \log \frac{m}{v}\right): \tag{18}$$

that in p, t, and μ is

$$p = a e^{\frac{\mathrm{H} - c - a}{a}} t^{\frac{c+a}{a}} e^{\frac{\mu - \mathrm{E}}{at}}, \tag{19}$$

where e denotes the base of the Naperian system of logarithms. As for the other constants, c denotes the specific heat of the

* Transactions of the Connecticut Academy, vol. ii, part 2.

gas at constant volume, a denotes the constant value of $pv \div mt$, E and H depend upon the zeros of energy and entropy. The two last equations may be abbreviated by the use of different constants. The properties of fundamental equations mentioned above may easily be verified in each case by differentiation.

The law of Dalton respecting a mixture of different gases affords a point of departure for the discussion of such mixtures and the establishment of their fundamental equations. It is found convenient to give the law the following form:

The pressure in a mixture of different gases is equal to the sum of the pressures of the different gases as existing each by itself at the same temperature and with the same value of its potential.

A mixture of ideal gases which satisfies this law is called an *ideal gas-mixture.* Its fundamental equation in p, t, μ_1, μ_2, etc. is evidently of the form

$$p = \Sigma_1 \left(a_1 e^{\frac{\mathrm{H}_1 - c_1 - a_1}{a_1}} t^{\frac{c_1 + a_1}{a_1}} e^{\frac{\mu_1 - \mathrm{E}_1}{a_1 t}} \right), \qquad (20)$$

where Σ_1 denotes summation with respect to the different components of the mixture. From this may be deduced other fundamental equations for ideal gas-mixtures. That in ψ, t, v, m_1, m_2, etc. is

$$\psi = \Sigma_1 \left(\mathrm{E}_1 m_1 + m_1 t \left(c_1 - \mathrm{H}_1 - c_1 \log t + a_1 \log \frac{m_1}{v} \right) \right). \qquad (21)$$

Phases of dissipated energy of ideal gas-mixtures.—When the proximate components of a gas-mixture are so related that some of them can be formed out of others, although not necessarily in the gas-mixture itself at the temperatures considered, there are certain phases of the gas-mixture which deserve especial attention. These are the *phases of dissipated energy*, i. e., those phases in which the energy of the mass has the least value consistent with its entropy and volume. An atmosphere of such a phase could not furnish a source of mechanical power to any machine or chemical engine working within it, as other phases of the same matter might do. Nor can such phases be affected by any catalytic agent. A *perfect catalytic agent* would reduce any other phase of the gas-mixture to a phase of dissipated energy. The condition which will make the energy a minimum is that the potentials for the proximate components shall satisfy an equation similar to that which expresses the relation between the units of weight of these components. For example, if the components were hydrogen, oxygen and water, since one gram of hydrogen with eight grams of oxygen are chemically equivalent to nine grams of water, the potentials for these substances in a phase of dissipated energy must satisfy the relation

$$\mu_{\mathrm{H}} + 8\mu_{\mathrm{O}} = 9\mu_{\mathrm{W}}.$$

Gas-mixtures with convertible components.—The theory of the phases of dissipated energy of an ideal gas-mixture derives an especial interest from its possible application to the case of those gas-mixtures in which the chemical composition and resolution of the components can take place in the gas-mixture itself, and actually does take place, so that the quantities of the proximate components are entirely determined by the quantities of a smaller number of ultimate components, with the temperature and pressure. These may be called *gas-mixtues with convertible components.* If the general laws of *ideal* gas-mixtures apply in any such case, it may easily be shown that the phases of dissipated energy are the only phases which can exist. We can form a fundamental equation which shall relate solely to these phases. For this end, we first form the equation in p, t, μ_1, μ_2, etc. for the gas-mixture, regarding its proximate components as *not* convertible. This equation will contain a potential for every proximate component of the gas-mixture. We then eliminate one (or more) of these potentials by means of the relations which exist between them in virtue of the convertibility of the components to which they relate, leaving the potentials which relate to those substances which naturally express the ultimate composition of the gas-mixture.

The validity of the results thus obtained depends upon the applicability of the laws of ideal gas-mixtures to cases in which chemical action takes place. Some of these laws are generally regarded as capable of such application, others are not so regarded. But it may be shown that in the very important case in which the components of a gas are convertible at certain temperatures, and not at others, the theory proposed may be established without other assumptions than such as are generally admitted.

It is, however, only by experiments upon gas-mixtures with convertible components, that the validity of any theory concerning them can be satisfactorily established.

The vapor of the peroxide of nitrogen appears to be a mixture of two different vapors, of one of which the molecular formula is double that of the other. If we suppose that the vapor conforms to the laws of an ideal gas-mixture in a state of dissipated energy, we may obtain an equation between the temperature, pressure, and density of the vapor, which exhibits a somewhat striking agreement with the results of experiment.

Equilibrium of stressed solids.—The second paper commences with a discussion of the conditions of internal and external equilibrium for solids in contact with fluids with regard to all possible states of strain of the solids. These conditions are deduced by analytical processes from the general condition of

equilibrium (2). The condition of equilibrium which relates to the dissolving of the solid at a surface where it meets a fluid may be expressed by the equation

$$\mu_1 = \frac{\varepsilon - t\eta + pv}{m}, \tag{22}$$

where ε, η, v, and m, denote respectively the energy, entropy, volume, and mass of the solid, if it is homogeneous in nature and state of strain,—otherwise, of any small portion which may be treated as thus homogeneous,—μ_1 the potential in the fluid for the substance of which the solid consists, p the pressure in the fluid and therefore one of the principal pressures in the solid, and t the temperature. It will be observed that when the pressure in the solid is isotropic, the second member of this equation will represent the potential in the solid for the substance of which it consists [see (9)], and the condition reduces to the equality of the potential in the two masses, just as if it were a case of two fluids. But if the stresses in the solid are not isotropic, the value of the second member of the equation is not entirely determined by the nature and state of the solid, but has in general three different values (for the same solid at the same temperature, and in the same state of strain) corresponding to the three principal pressures in the solid. If a solid in the form of a right parallelopiped is subject to different pressures on its three pairs of opposite sides by fluids in which it is soluble, it is in general necessary for equilibrium that the composition of the fluids shall be different.

The *fundamental equations* which have been described above are limited, in their application to solids, to the case in which the stresses in the solid are isotropic. An example of a more general form of fundamental equation for a solid, is afforded by an equation between the energy and entropy of a given quantity of the solid, and the quantities which express its state of strain, or by an equation between ψ [see (3)] as determined for a given quantity of the solid, the temperature, and the quantities which express the state of strain.

Capillarity.—The solution of the problems which precede may be regarded as a first approximation, in which the peculiar state of thermodynamic equilibrium about the surfaces of discontinuity is neglected. To take account of the condition of things at these surfaces, the following method is used. Let us suppose that two homogeneous fluid masses are separated by a surface of discontinuity, i. e., by a very thin non-homogeneous film. Now we may imagine a state of things in which each of the homogeneous masses extends without variation of the densities of its several components, or of the densities of energy and entropy, quite up to a geometrical surface (to be called the divid-

ing surface) at which the masses meet. We may suppose this surface to be sensibly coincident with the physical surface of discontinuity. Now if we compare the actual state of things with the supposed state, there will be in the former in the vicinity of the surface a certain (positive or negative) excess of energy, of entropy, and of each of the component substances. These quantities are denoted by ε^S, η^S, m_1^S, m_2^S, etc. and are treated as belonging to the surface. The ^{S} is used simply as a distinguishing mark, and must not be taken for an algebraic exponent.

It is shown that the conditions of equilibrium already obtained relating to the temperature and the potentials of the homogeneous masses, are not affected by the surfaces of discontinuity, and that the complete value of $d\varepsilon^S$ is given by the equation

$$\delta\varepsilon^S = t\,\delta\eta^S + \sigma\,\delta s + \mu_1\,\delta m_1^S + \mu_2\,\delta m_2^S + \text{ etc.} \tag{23}$$

in which s denotes the area of the surface considered, t the temperature, μ_1, μ_2, etc. the potentials for the various components in the adjacent masses. It may be, however, that some of the components are found only at the surface of discontinuity, in which case the letter μ with the suffix relating to such a substance denotes, as the equation shows, the rate of increase of energy at the surface per unit of the substance added, when the entropy, the area of the surface, and the quantities of the other components are unchanged. The quantity σ we may regard as defined by the equation itself, or by the following, which is obtained by integration:

$$\varepsilon^S = t\,\eta^S + \sigma\,s + \mu_1\,m_1^S + \mu_2\,m_2^S + \text{ etc.} \tag{24}$$

There are terms relating to variations of the curvatures of the surface which might be added, but it is shown that we can give the dividing surface such a position as to make these terms vanish, and it is found convenient to regard its position as thus determined. It is always sensibly coincident with the physical surface of discontinuity. (Yet in treating of plane surfaces, this supposition in regard to the position of the dividing surface is unnecessary, and it is sometimes convenient to suppose that its position is determined by other considerations.)

With the aid of (23), the remaining condition of equilibrium for contiguous homogeneous masses is found, viz:

$$\sigma\,(c_1 + c_2) = p' - p'', \tag{25}$$

where p', p'' denote the pressures in the two masses, and c_1, c_2 the principal curvatures of the surface. Since this equation has the same form as if a tension equal to σ resided at the surface, the quantity σ is called (as is usual) the *superficial tension*, and the dividing surface in the particular position above mentioned is called the *surface of tension*.

By differentiation of (24) and comparison with (23), we obtain

$$d\sigma = -\eta_S dt - \Gamma_1 d\mu_1 - \Gamma_2 d\mu_2 - \text{etc.}, \tag{26}$$

where η_S, Γ_1, Γ_2, etc. are written for $\frac{\eta^S}{s}$, $\frac{m_1^S}{s}$, $\frac{m_2^S}{s}$, etc., and denote the superficial densities of entropy and of the various substances. We may regard σ as a function of t, μ_1, μ_2, etc., from which if known η_S, Γ_1, Γ_2, etc. may be determined in terms of the same variables. An equation between σ, t, μ_1, μ_2, etc. may therefore be called a *fundamental equation for the surface of discontinuity.* The same may be said of an equation between ϵ^S, η^S, s, m_1^S, m_2^S, etc.

It is necessary for the stability of a surface of discontinuity that its tension shall be as small as that of any other surface which can exist between the same homogeneous masses with the same temperature and potentials. Beside this condition, which relates to the nature of the surface of discontinuity, there are other conditions of stability, which relate to the possible motion of such surfaces. One of these is that the tension shall be positive. The others are of a less simple nature, depending upon the extent and form of the surface of discontinuity, and in general upon the whole system of which it is a part. The most simple case of a system with a surface of discontinuity is that of two coëxistent phases separated by a spherical surface, the outer mass being of indefinite extent. When the interior mass and the surface of discontinuity are formed entirely of substances which are components of the surrounding mass, the equilibrium is always unstable; in other cases, the equilibrium may be stable. Thus, the equilibrium of a drop of water in an atmosphere of vapor is unstable, but may be made stable by the addition of a little salt. The analytical conditions which determine the stability or instability of the system are easily found, when the temperature and potentials of the system are regarded as known, as well as the fundamental equations for the interior mass and the surface of discontinuity.

The study of surfaces of discontinuity throws considerable light upon the subject of the stability of such phases of fluids as have a less pressure than other phases of the same components with the same temperature and potentials. Let the pressure of the phase of which the stability is in question be denoted by p', and that of the other phase of the same temperature and potentials by p''. A spherical mass of the second phase and of a radius determined by the equation

$$2\,\sigma = (p'' - p')\,r, \tag{27}$$

would be in equilibrium with a surrounding mass of the first phase. This equilibrium, as we have just seen, is instable, when the surrounding mass is indefinitely extended. A spherical

mass a little larger would tend to increase indefinitely. The work required to form such a spherical mass, by a reversible process, in the interior of an infinite mass of the other phase, is given by the equation

$$W = \sigma s - (p'' - p')\, v''. \tag{28}$$

The term σs represents the work spent in forming the surface, and the term $(p'' - p')\, v''$ the work gained in forming the interior mass. The second of these quantities is always equal to two-thirds of the first. The value of W is therefore positive, and the phase is in strictness stable, the quantity W affording a kind of measure of its stability. We may easily express the value of W in a form which does not involve any geometrical magnitudes, viz:

$$W = \frac{16\,\pi\,\sigma^3}{3(p'' - p')^2}, \tag{29}$$

where p'', p' and σ may be regarded as functions of the temperature and potentials. It will be seen that the stability, thus measured, is infinite for an infinitesimal difference of pressures, but decreases very rapidly as the difference of pressures increases. These conclusions are all, however, practically limited to the case in which the value of r, as determined by equation (27) is of sensible magnitude.

With respect to the somewhat similar problem of the stability of the surface of contact of two phases with respect to the formation of a new phase, the following results are obtained. Let the phases (supposed to have the same temperature and potentials) be denoted by A, B, and C; their pressures by p_A, p_B and p_C; and the tensions of the three possible surfaces σ_{AB}, σ_{BC}, σ_{AC}. If p_C is less than

$$\frac{\sigma_{BC}\, p_A + \sigma_{AC}\, p_B}{\sigma_{BC} + \sigma_{AC}},$$

there will be no tendency toward the formation of the new phase at the surface between A and B. If the temperature or potentials are now varied until p_C is equal to the above expression, there are two cases to be distinguished. The tension σ_{AB} will be either equal to $\sigma_{AC} + \sigma_{BC}$ or less. (A greater value could only relate to an unstable and therefore unusual surface.) If $\sigma_{AB} = \sigma_{AC} + \sigma_{BC}$, a farther variation of the temperature or potentials, making p_C greater than the above expression, would cause the phase C to be formed at the surface between A and B. But if $\sigma_{AB} < \sigma_{AC} + \sigma_{BC}$, the surface between A and B would remain stable, but with rapidly diminishing stability, after p_C has passed the limit mentioned.

The conditions of stability for a line where several surfaces of discontinuity meet, with respect to the possible formation of

a new surface, are capable of a very simple expression. If the surfaces A-B, B-C, C-D, D-A, separating the masses A, B, C, D, meet along a line, it is necessary for equilibrium that their tensions and directions at any point of the line should be such that a quadrilateral α, β, γ, δ may be formed with sides representing in direction and length the normals and tensions of the successive surfaces. For the stability of the system with reference to the possible formation of surfaces between A and C, or between B and D, it is farther necessary that the tensions σ_{AC} and σ_{BD} should be greater than the diagonals $\alpha\gamma$ and $\beta\delta$ respectively. The conditions of stability are entirely analogous in the case of a greater number of surfaces. For the conditions of stability relating to the formation of a new phase at a line in which three surfaces of discontinuity meet, or at a point where four different phases meet, the reader is referred to the original paper.

Liquid films.—When a fluid exists in the form of a very thin film between other fluids, the great inequality of its extension in different directions will give rise to certain peculiar properties, even when its thickness is sufficient for its interior to have the properties of matter in mass. The most important case is where the film is liquid and the contiguous fluids are gaseous. If we imagine the film to be divided into elements of the same order of magnitude as its thickness, each element extending through the film from side to side, it is evident that far less time will in general be required for the attainment of approximate equilibrium between the different parts of any such element and the contiguous gases than for the attainment of equilibrium between all the different elements of the film.

There will accordingly be a time, commencing shortly after the formation of the film, in which its separate elements may be regarded as satisfying the conditions of internal equilibrium, and of equilibrium with the contiguous gases, while they may not satisfy all the conditions of equilibrium with each other. It is when the changes due to this want of complete equilibrium take place so slowly that the film appears to be at rest, except so far as it accommodates itself to any change in the external conditions to which it is subjected, that the characteristic properties of the film are most striking and most sharply defined. It is from this point of view that these bodies are discussed. They are regarded as satisfying a certain well-defined class of conditions of equilibrium, but as not satisfying at all certain other conditions which would be necessary for complete equilibrium, in consequence of which they are subject to gradual changes, which ultimately determine their rupture.

The elasticity of a film (i. e., the increase of its tension when extended,) is easily accounted for. It follows from the general

relations given above that, when a film has more than one component, those components which diminish the tension will be found in greater proportion on the surfaces. When the film is extended, there will not be enough of these substances to keep up the same volume- and surface-densities as before, and the deficiency will cause a certain increase of tension. It does not follow that a thinner film has always a greater tension than a thicker formed of the same liquid. When the phases within the films as well as without are the same, and the surfaces of the films are also the same, there will be no difference of tension. Nor will the tension of the same film be altered, if a part of the interior drains away in the course of time, without affecting the surfaces. If the thickness of the film is reduced by evaporation, its tension may be either increased or diminished, according to the relative volatility of its different components.

Let us now suppose that the thickness of the film is reduced until the limit is reached at which the interior ceases to have the properties of matter in mass The elasticity of the film, which determines its stability with respect to extension and contraction, does not vanish at this limit. But a certain kind of instability will generally arise, in virtue of which inequalities in the thickness of the film will tend to increase through currents in the interior of the film. This probably leads to the destruction of the film, in the case of most liquids. In a film of soap-water, the kind of instability described seems to be manifested in the breaking out of the black spots. But the sudden diminution in thickness which takes place in parts of the film is arrested by some unknown cause, possibly by viscous or gelatinous properties, so that the rupture of the film does not necessarily follow.

Electromotive force.—The conditions of equilibrium may be modified by electromotive force. Of such cases a galvanic or electrolytic cell may be regarded as the type. With respect to the potentials for the ions and the electrical potential the following relation may be noticed:

When all the conditions of equilibrium are fulfilled in a galvanic or electrolytic cell, the electromotive force is equal to the difference in the values of the potential for any ion at the surfaces of the electrodes multiplied by the electro-chemical equivalent of that ion, the greater potential of an anion being at the same electrode as the greater electrical potential, and the reverse being true of a cation.

The relation which exists between the electromotive force of a *perfect electro-chemical apparatus* (i. e., a galvanic or electrolytic cell which satisfies the condition of reversibility,) and the changes in the cell which accompany the passage of electricity, may be expressed by the equation

$$d\varepsilon = (V' - V'')\, de + t\, d\eta + d W_G + d W_P, \qquad (30)$$

in which $d\epsilon$ denotes the increment of the intrinsic energy in the apparatus, $d\eta$ the increment of entropy, de the quantity of electricity which passes through it, V' and V'' the electrical potentials in pieces of the same kind of metal connected with the anode and cathode respectively, dW_G the work done by gravity, and dW_P the work done by the pressures which act on the external surface of the apparatus. The term dW_G may generally be neglected. The same is true of dW_P, when gases are not concerned. If no heat is supplied or withdrawn the term $t\,d\eta$ will vanish. But in the calculation of electromotive forces, which is the most important application of the equation, it is convenient and customary to suppose that the temperature is maintained constant. Now this term $t\,d\eta$, which represents the heat absorbed by the cell, is frequently neglected in the consideration of cells of which the temperature is supposed to remain constant. In other words, it is frequently assumed that neither heat or cold is produced by the passage of an electrical current through a perfect electro-chemical apparatus (except that heat which may be indefinitely diminished by increasing the time in which a given quantity of electricity passes), unless it be by processes of a secondary nature, which are not immediately or necessarily connected with the process of electrolysis.

That this assumption is incorrect is shown by the electromotive force of a gas battery charged with hydrogen and nitrogen, by the currents caused by differences in the concentration of the electrolyte, by electrodes of zinc and mercury in a solution of sulphate of zinc, by *a priori* considerations based on the phenomena exhibited in the direct combination of the elements of water or of hydrochloric acid, by the absorption of heat which M. Favre has in many cases observed in a galvanic or electrolytic cell, and by the fact that the solid or liquid state of an electrode (at its temperature of fusion) does not affect the electromotive force.

ART. LIII.—*On an Anatomical Peculiarity by which Crania of the Mound builders may be distinguished from those of the Modern Indians;** by W. J. McGEE, Farley, Iowa.

THE difficulty of determining whether a skull from a mound belonged to a modern Indian or to an individual of the mysterious race which erected the mounds of the Mississippi Valley is well known; and so complex is the problem that only an anatomist of long experience and tried skill can satisfactorily solve it. Even then it frequently happens that "doctors

* Read before the American Association for the Advancement of Science at St. Louis.

disagree;" as when Col. Foster, at one time president of this Association, declared that the only cranium figured by Squier and Davis in their great work on the "Ancient Monuments of the Mississippi Valley" as representative of the cranial structure of the Mound-builders, did not belong to that race at all. Any observations throwing light on the question of the relations of these crania will therefore be of practical value.

The writer has made a pretty thorough study of the archæology of northeastern Iowa, and has examined several skulls unearthed in that region, as well as some from Wisconsin, Illinois and Kentucky. The total number of Mound-builders' crania examined will not, however, exceed fifty or seventy-five; and a part of these were fragmentary. Hence the observations cannot be considered to afford a perfectly reliable guide in the determination of crania, and too great weight should not be attached to them until verified by authentic cases of a similar nature from other quarters. At present they have but a provisional significance. The structural peculiarity which has been found to be a more trustworthy distinguishing feature than differences in the capacity or general contour of the skulls, relative length and breadth, thickness of walls, or condition and state of preservation of the bone, is the greater relative size of the posterior molars or "wisdom teeth" in both maxillaries of the Mound-builders' crania than in those of the recent red race. Measurements have not been made to illustrate this difference in relative size, principally because the preparation of this paper was occasioned by the discussion following the reading on yesterday morning of an archæological paper in this section, since which time specimens from which dimensions could be taken have not been accessible.

Aside from the simple difference in relative size of the posterior and anterior molars, it seems that the "wisdom teeth" were earlier developed in the individuals of the Mound-building race than in either the Indian or the white man. It is well known that the posterior molars do not usually appear in civilized man until near maturity. Exceptions to this rule are not infrequent but they may be put down as cases of reversion. That this is warrantable will be more obvious further on. Again, these teeth are rarely so fully developed during the lifetime of the individual, in the white races, as to have their grinding surfaces worn down equally with the anterior molars. They therefore partake to some extent of the nature of rudimentary organs. In crania from the mounds, which were from young individuals as attested by the imperfect anchylosis of the sutures permitting fractures to easily occur along these lines, sometimes even the complete decomposition of the symphyses supervened, these

teeth have been found fully developed and the grinding surface nearly or quite as far worn down as in their anterior neighbors. In more mature crania the surface of the posterior molar is usually the largest and apparently the most worn down. Hence in the Mound-builder this tooth was not by any means rudimentary, but was a useful organ throughout nearly the whole of the lifetime of its possessor.

The corresponding tooth of the modern Indian occupies—if the Indian crania examined were typical, as they seemed to be—an intermediate stage in development between that of the Mound-builder on the one hand and that of the Caucassian on the other. As to the period at which the tooth makes its appearance and when it reaches its full development, the writer has been able to learn nothing thus far. This point seems to have escaped the notice of ethnologists heretofore. The difference in relative size and in the comparative maturity of these teeth is sufficient, however, in nearly all the specimens examined, to allow of their ready determination. Nevertheless this rule could not be indiscriminately applied, as due allowance must be made for differences in age, etc., of the individual; but with care and judgment the writer is convinced that it is competent.

The greater development of the posterior molars seems to be common to the lower and earlier races. This peculiarity has been observed in several of the fossil skulls of paleolithic man exhumed in Europe, as in the jaw-bone from the cave of Naulette, Belgium, in which, as reported by the Belgian geologists, the molar teeth increased in size backward. Dr. E. Lambert, of Brussels, has recently made an extensive collection of crania of various races, and has found that the posterior molar is relatively larger, not only in the red but in the black races than in the Caucassian. The dentation of the yellow races, however, corresponds more nearly with that of the white.* So far as known to the writer Dr. Lambert has not noted the period of development of these teeth in any of the races.

This morphological variation in the different stocks of mankind is probably a concomitant of the principle of cephalization if not directly coördinated therewith. It has been shown by Prof. Dana that cephalization is "a fundamental principle in the development of the system of animal life,"† and that there has been an increase in cerebral volume in many if not all mammals since early cenozoic time; and Professor Marsh has shown that this tendency is manifested in a striking degree

* Scientific American, vol. xxxviii, p. 98.

† This Journal, III, vol. xii, October, 1876, p. 245. References to Professor Marsh's papers are given in this memoir.

in the Eocene Dinoceras and Coryphodon, in the Miocene Brontotherium, and in the Pliocene Mastodon. But the researches of Marsh, Leidy, Cope, Hayden and others, in the Cretaceous and Tertiary beds of the western territories have shown us that there is a concurrent tendency toward a decrease in size of the posterior and increase in size of the anterior molars observable in perhaps any class of mammals which we may examine. The tendency is just as plainly marked as that toward increase in cranial capacity or toward compactness and abbreviation of the anterior organs,—indeed it is undoubtedly correlated with the shortening and compacting of the jaws. And it is probable that the degree of development of any mammal, as the horse or pig, can be just as readily and reliably measured by the relative size of its molars as by the size of its brain-case or by the presence or absence of certain bones of manus or pes. Casual statements to the effect that the relative size of the posterior molar varies inversely as the volume of the brain have indeed been met with, but no critical discussion of the true significance of such relations; and their practical bearing on the work of the determination of native American crania seems to have been wholly overlooked, as it certainly was in the discussion of yesterday.

Planters' Hotel, St. Louis, Aug. 23, 1878.

ART. LIV.—*On the Limits of Hypotheses regarding the Properties of the Matter composing the Interior of the Earth;* by HENRY HENNESSY, F.R.S., Professor of Applied Mathematics in the Royal College of Science for Ireland.*

1. FROM direct observation we are able to obtain only a very moderate knowledge of the materials existing below the solid crust of the earth. The depth to which we can penetrate by mining and boring operations into this crust is comparatively insignificant; and these operations give us little knowledge of the earth's interior in comparison with what is afforded by the outporings of volcanoes. Two hundred active volcanoes are said to still exist, while geologists have established that many thousands of such deep apertures in the earth's crust have existed during remote epochs of its physical history. The source or sources of supply for all these volcanoes have poured out a predominating mass of matter in a state of liquidity from fusion. Evidence is thus furnished that matter in a state of fluidity exists very widely distributed through the earth. The

*** From the Phil. Mag. for Oct., 1878. Read before the Mathematical and Physical Section of the British Association for the Advancement of Science, Dublin, August, 1878.**

supposition that this fluid fills the whole interior, and that the solid crust is a mere exterior envelope, is usually designated as the hypothesis of internal fluidity. From this hypothesis mechanical and physical results of primary importance in terrestrial physics may be deduced.

Newton, Clairaut, Laplace, Airy, and other illustrious mathematicians have used an extension of this hypothesis in discussing the earth's figure. They supposed the particles composing the earth to retain the same positions after solidification as that which they held before it. I ventured, for the first time, to discard the latter portion of the hypothesis as useless and contrary to physical laws. I now venture to say that, in framing any hypotheses as to the physical character of the matter of the earth, we should not affix any property to the supposed matter which is opposed to the properties observed in similar kinds of matter coming under our direct observation. Observation has disclosed that liquids are in general viscid, and that they possess what has been designated internal friction in a high degree.* Observation has recently shown that among the three states of matter (gaseous, liquid and solid) a law of continuity exists. Observation also discloses that gases and vapors are, of all forms of matter, the most compressible, that liquids are much less compressible, and that solids are still less compressible. Thus, for instance, water is about fourteen times more compressible than copper or brass.

2. If these general comparative properties of liquids and solids are admitted, it follows that in the hypotheses regarding the earth's internal structure we should most carefully guard against any assumption directly in contradiction to such properties. By assuming that the earth contained a fluid totally devoid of viscidity and internal friction, the late Mr. Hopkins attempted to prove the earth's entire solidity. He only proved that it did not contain any of this imaginary fluid; but he by no means proved the non-existence of a liquid possessing the properties of viscidity and internal friction common to all liquids. In the Comptes Rendus of the Academy of Sciences of Paris for 1871 is a paper in which I have given a *résumé* of the arguments against Mr. Hopkins's conclusions as to the earth's complete solidity; and in the subsequent discussions my priority on this matter seems to have been fairly and honorably acknowledged.† In a recent admirable work on

* As having a special connection with this subject, see a Report by the Author on Experiments on the influence of the molecular condition of fluids, on their motion when in rotation and in contact with solids (Proceedings of the Royal Irish Academy, 2nd series, vol. iii, p. 55).

† "Remarques à propos d'une Communication de M. Delaunay sur les résultats fournis par l'Astronomie concernant l'épaisseur de la croûte solide du Globe," *Comptes Rendns de l'Inst. France*, Mars 6, 1871, p. 250.

Geology, Pfaff's Grundriss der Geologie, the author gives a brief account of the bearing of astronomical and mathematical investigations on the internal structure of the earth; and he very justly says that the results of observation compel us to regard the earth as for the most part fluid, in order to bring these results into harmony with calculation. Professor Pfaff attributes this conclusion to Hopkins, whereas it is precisely that which I had long since enunciated, and is entirely opposed to the views of Mr. Hopkins. More recently Sir William Thomson and Mr. Darwin have investigated the tidal action of an internal fluid nucleus upon its containing solid shell. They have both supposed the liquid to be totally incompressible, and the containing vessel to be elastic and therefore compressible. They have thus given the liquid a property which no liquid in existence possesses, and the solid a property which solids possess in a much less degree than liquids. Their hypothesis is thus totally inadmissible as a part of the problem of inquiry into the earth's structure. I at once admit that a thin elastic spheroidal envelope filled with incompressible liquid and subjected to the attraction of exterior bodies would present periodical deformations, owing to tidal action far surpassing the tides of the ocean. But I do not admit that such impossible substances can represent the materials of the earth. My hypothesis is that the liquid interior matter, instead of being incompressible, is, like all liquids we observe, relatively far more compressible than its solid envelope. A highly compressible liquid contained in a very much less-compressible shell would be a hypothesis more in harmony with physical observation. The tidal phenomena of a compressible fluid, it is easy to see, would be very different from those of an incompressible fluid. The work done by the action of certain disturbing bodies in the strata of compressible fluid would partly result in causing variations of density, instead of producing tidal waves of great magnitude. This has been already shown in the Mécanique Céleste by Laplace, in discussing the tides of the atmosphere. Theory shows that the atmospheric tides should be nearly insensible, notwithstanding the great depth of the atmospheric column, because the work done in the atmosphere is very different from what is performed in the less-compressible water of the ocean. Observation has fully verified this result.

3. It is admitted that the earth's density increases from its surface toward its center. If its interior is occupied by a compressible fluid, the law of density of this fluid would result from the compression of its own strata; just as the law of density of the atmosphere is produced by the pressure of the upper atmospheric layers upon those below. But instead of supposing the interior of the earth to be filled by a fluid thus con-

forming to the observed properties of fluids, both Sir William Thomson and Mr. Darwin have applied their great powers as accomplished mathematicians to the tides of an incompressible and homogeneous spheroid, such as I admit to have no real existence whatsoever.

4. The labor bestowed on the problem investigated could scarcely be considered at all necessary or fruitful, except as affording an admirable illustration of the results flowing from the employment of hypotheses framed in direct contradiction to the fundamental conditions to which every truly philosophical hypothesis must conform. It is scarcely necessary to add, that the conclusions of Mr. Darwin, as well as those of Sir William Thomson, cannot be considered as having invalidated the carefully framed hypothesis that the earth consists of a solid crust physically similar to the rocks we are enabled to observe, and a contained spheroid of liquids and physically similar to the liquid rock poured out by volcanic openings.

5. It is with much satisfaction that I can trace a gradual growth of more correct physical views on the questions referred to in this paper. In Nature, vol. v, p. 288, a paper appeared in which I ventured to criticise Sir William Thomson's memoir on the Rigidity of the Earth, in the Philosophical Transactions. At the Meeting of the British Association in Glasgow, Sir William Thomson acknowledged the invalidity of many of his arguments, and requested his audience to draw their pens through paragraphs from 23 to 31 in his paper. These paragraphs contain statements and reasonings which I had already shown to be inconclusive in the paper which has just been quoted.

In Mr. Darwin's paper, recently communicated to the British Association, he admits that in discussing the precessional and tidal phenomena of a viscous liquid, the supposition of an elastic spheroid would lead to *very different* results—that is to say, results very different from those deduced by himself and Sir William Thomson regarding the earth's structure, and which the followers of the late Sir Charles Lyell have frequently assumed to be established. Thus the late Mr. Poulett Scrope appears to have referred to the bearing of the mathematical investigations alluded to, on what he calls "the sensational idea" of an internal incandescent fluid beneath the solid crust of the earth. He forgot that an idea may not be the less true because it is sensational. The idea of antipodes was at one time regarded as highly sensational. Those who witness a great earthquake or volcanic eruption are usually impressed with the sensational character of the phenomena.

6. A traveller who was in Portugal more than forty years since, met a woman over one hundred years of age, and asked

her if she recollected the great earthquake of Lisbon. She replied, that it was the event of all others in her long life which she ought to vividly recollect, on account of its impressive sensations. History also records the sensational character of the destruction of Pompeii. If Mr. Scrope's innuendo regarding the internal fluidity of the earth as "a sensational hypothesis" has any value, we should regard the events referred to as highly improbable; yet they have been as well authenticated as the most positive facts in science, and no person has ever expressed the smallest shadow of a doubt as to their occurrence.

ART. LV.—*Discoveries in Western Caves*; by Rev. HORACE C. HOVEY, M.A.

THE following notes are selected from a large mass of descriptive material, collected by the writer during recent underground explorations in some of the States of the Mississippi Valley.

1. *Silurian Caves.*—Especial attention was paid to these caves in view of the "grave doubts" of a distinguished geologist "whether in a single case they extend much beyond the light of day."* His remark refers to the upper hundred feet of the Cincinnati group. An excellent opportunity for the study of caves in this Lower Silurian rock is afforded in bluffs about Madison, Indiana, which rise 400 feet from the thin strata characteristic of that formation, to the massive rocks of the Niagara limestone. Each stream, as it plunges down from the table-land above, washes out the lower layers, leaving the upper as an overhanging ledge. In time, the shallow grotto behind the cascade expands into a spacious amphitheater, 200 or 300 feet wide and nearly as many deep. The roof generally falls by its own weight when these dimensions are exceeded; and the result is finally a ravine with steep walls, encumbered below with large fragments of stone. An examination of the region for twenty miles north of Madison led to our discovering, not only sinks, natural wells, rock-houses and water-swept chasms, but also true caverns, whose roof is the solid limestone of the Upper Silurian, while the excavation itself is in the softer rocks of the Lower. Two miles west of Hanover, Indiana, is a stream that flows toward the Wabash from the very banks of the Ohio. It emerges from a tunnel which is easily threaded for half a mile, and continues uncovered for fifty feet; and then

* Geological Survey of Kentucky (Shaler), vol. i, p. 4.

it again recedes by a second opening. We followed its course through roomy halls rich in stalactites to a waterfall fifteen feet high, where the exploration terminated. The entire distance traversed was, by estimate, one mile and a half—a greater length than that of Weyer's Cave. The credit of discovering this *Silurian* cavern belongs to Messrs. Monfort and Thomson; and as it is now for the first time described, it may be appropriately named the Hanover Cave.

2. *Sub-Carboniferous Caves.*—The procedure of the brook described above is reversed in the case of Lost River, which, after receiving tributaries and increasing in volume, flows *into* a cavernous opening and continues for miles along a subterranean channel, alternately rising to the surface and sinking again several times before it finally emerges a mile below Orangeville, Indiana. These "rises" as they are called, are generally marked by gulfs denoting the fall of superincumbent rocks; at one of them a small boat has been put upon the stream, it having been found to be navigable for a long distance under ground. Lost River flows amid bluffs of the Saint Louis group, carved by erosion into numerous ravines and sink-holes, and the latter so thoroughly underdrain the region as to cause a remarkable absence of springs, brooks and ponds.

These phenomena are instructive as to the production of the countless caves that honey-comb the Sub-carboniferous rocks of Kentucky and Southern Indiana. A compact and homogeneous limestone, varying from 25 feet to 440 feet in measured thickness, lies between the surface and the level of natural drainage, subject to the dissolving and eroding action of running water. The result, in time, is a succession of arches, galleries and avenues, presenting wonderful and grotesque combinations to the explorer when the stream that has caused them is withdrawn to some other channel. The slow trickling of limewater furnishes materials for the growth of stalactites that tend to gradually close up and obliterate these deserted halls. Should Lost River find another channel, the cave which would remain might equal in proportions any hitherto discovered. There are no doubt numerous unexplored and nameless caves that would richly reward those whose love of adventure should lead them to follow out their ramifications. Professor Shaler estimates that, in Kentucky, "there are at least 100,000 miles of open cavern beneath the surface of the Carboniferous limestone;" and my own observations lead to the conclusion that there are thousands of miles of such subterranean avenues beneath the same formation in Indiana. Yet the public should be cautious in yielding credence to cave-stories. Articles appeared in Louisville papers less than a year ago, and were copied and believed in this country, and

even found their way into foreign periodicals, that purported to describe the "Grand Crystal Cave near Glasgow, Kentucky" giving thrilling particulars of a perilous voyage on its mysterious waters. We ascertained by inquiry on the spot that no such cave exists; and have learned by experience that cave-streams are generally very safe and placid bodies of water, by reason of the fact that they are not of navigable size until the level of adjacent streams is nearly reached.

3. *Mammoth Cave* is visited by more than 2,000 persons annually, and its noteworthy features have been repeatedly described. Tourists are usually content with either the Short or the Long route, both of which can be traversed in a single day. We, however, were favored with a special guide, and devoted many successive days to localities not often visited. After eighty miles of underground travel, our curiosity was satiated; and yet we had entered only 54 of the 225 avenues reported by Professor D. D. Owen as actually enumerated. The comparatively recent discovery of a pit-like passage called "the Corkscrew," is of importance, not only because it enables the visitors to cut off two miles between the Rotunda and River Hall by an abrupt descent of 150 feet; but also because it proves the theory that the cave crosses its own track, so that a change is required in the entire map. It is now believed that the cascade falling over the mouth and instantly sinking through the rocks is identical with that at the head of the River Styx, and is a feeder of that stream. It is also proved that these deep and navigable rivers, instead of being fed by Green River, flow into it. Chaff thrown upon the surface of Lake Lethe reappears after some time in the waters of what is known as the Upper Big spring; while that thrown upon Echo River comes out at the Lower spring. The fact that Green River is thus replenished explains the peculiarity of its never being frozen over even in the coldest winter. It may be added that as the water-level is known to be 312 feet below the crest of the hill covering the cave, the subterranean rivers must be at a little less than that number of feet beneath the surface, and must also be the lowest localities possible. Hence no dome in Mammoth Cave could exceed 312 feet in height without cutting through to the open air; by which test may be corrected the statements of those imaginative writers whose estimates are nearly double what they should be. The grandest of these vertical cavities, piercing from some sink-hole above through all the galleries down to the water-level, is called, by way of eminence, the Mammoth Dome. Beyond it lies a stately hall, so like the ruins of Karnak and Luxor that we had permission to name it the Egyptian Temple. Here stand six columns of oölitic limestone encrusted with a stalagmitic coating but an inch or two

in thickness and as yellow as jasper. We measured one that arose eighty feet from what we regarded as its base to the ceiling, and found it twenty-six feet in its longest diameter Descending into a pit, we found what we named the Catacombs, opening into an avenue about three miles long.

The acoustic properties of Echo River passage-way are extraordinary. This body of water is said to be rather less than one mile in length and to be forty or fifty feet deep. The continued arch of natural masonry by which it is spanned, varies in height from three to thirty feet. The echo is a musical prolongation of sound, rather than a distinct repetition of words, although this also may be obtained. Harmonics were produced in reponse to certain key-notes. A strong vocal impulse was prolonged with sustained vigor for fifteen seconds, and in the opinion of others for a longer time; the duration depending much on our location on the water, the purity of tone, the pitch and the energy of the original aërial vibrations. By silently but forcibly pushing the water to and fro with a broad paddle, successive wavelets were sent into numerous marginal cavities, awakening chimes that continued for from three to ten minutes according to the violence of the agitation, dying away as the river regained a state of quiescence.

The average temperature of the cave has long been reported incorrectly to be 59° Fahr. Temperature observations were made by us in all parts of the cave that we visited, using a thermometer from the Tower Company, Chester, Pennsylvania, which indicated 88° in the hotel office (August 19th, 1878,) and 66° at the cave's mouth. We were careful to suspend the instrument by its ring in each instance, and to hold it at a distance from the person and the lamp; particulars about which others may not have taken sufficient pains. The mercury stood highest in the Rotunda, where it reached 58°. The lowest temperature was found in Lucy's Dome, namely, 54°. It was 57° in three places: but in forty-two observations the mercury stood at 56°. The water in all the rivers was also at 56°, instead of at 54°, as often stated. In three springs the mercury fell to 53°, and in one, Richardson's Spring, to 52°, which was the lowest degree marked anywhere. The temperature of the rivers is identical with that of the atmosphere over them; the apparent difference being due to variation in conductivity. The average temperature of the cave may be fixed at 56°.

4. *Wyandot Cave.*—The entrance to Wyandot cave is in Crawford County, Indiana, half a mile from Blue River and five miles from the Ohio. A map of the cave was prepared by Dr. Talbot in 1852, revised by me in 1854, and published in Owen's Indiana Geological Report, in 1860. A new map is shortly to appear noting corrections and recent discoveries. The length

of the cave is twenty-three miles, including all the avenues. It has many fine halls and domes, the largest of which has a circumference of 1,000 feet, and is said to be 205 feet high. The name has hitherto been Mammoth Hall; but it is now re-named Rothrock's Cathedral, to avoid confusion, and also as a tardy recognition of the worthy man who originally purchased the place from the government and left it as a heritage to his sons. Wyandot Cave should be visited even by those who have already explored the greater cavern of Kentucky; for it is far richer in stalactitic ornamentation, although less abounding in gypsum rosettes or "oulopholites." The stalactites are of the fine-grained translucent kind often called alabaster, and much resembling the Mexican onyx.

Thermometrical observations, made by the same instrument and methods used in Mammoth Cave, showed that, while the temperature of the outer air was 76°, that of Wyandot Cave averaged 55½°. The highest temperature was found in the Pillared Palace, 57°; the lowest in the Wyandot's Council-room, 54°; elsewhere, out of twenty-two observations, an equal number indicated 55° and 56°. In two springs the water was found to have a temperature of 52°, and in one of 54°. Thus, instead of being, as has often been said, 6° colder than Mammoth Cave, we found it only half a degree colder.

An important discovery was made last April by a party of students from Wabash College, led by Mr. C. E. Milroy. Forcing their way through a low, narrow passage for fifty feet from a locality marked on the map as the Rugged Pass, they entered a realm of chaos, named, after its discoverer, Milroy's Temple. Pits, miry banks, huge rocks, are overhung by galleries of creamy stalactites, vermicular tubes intertwined, frozen cataracts and all in short that nature could do in her wildest and most fantastic mood. Among the many curiosities of this extraordinary place is a row of musical stalactites, very broad and thin, on which a chord can be struck or a melody played by a skillful hand. This discovery has stimulated research. We ourselves followed the guide through a trench dug by him in a clay-bank, into a chamber where the floor was thickly strewn with charred fragments of hickory bark, and two torches long extinct were sticking in a crevice in the low ceiling. The tracks of some wild beast were also found which led us to name the place the Wolf's Lair. The roof seems to have fallen in since the torches were left here; and our compass told us that the closed avenue must have led to Banditti Hall, within 1,200 feet of the mouth. Animals of various kinds are known to have frequented this cave in former days. We saw the skeleton of an opossum and also of a wild cat, besides many stout poles from five to eight feet long, marked by sharp teeth in some ancient contest. "Bear-slides" are shown in several

places, where the rocks are blackened and polished as if by the rubbing of fur. "Bear-wallows," are also pointed out; but on our recent visit we discovered this to be a misnomer.

Bands of black flint are found in the limestones of the south arm of the cave, sometimes in continuous belts, but oftener in rows of nodules varying in size from one to ten inches. Occasionally they have a geodic form and a crystalline center, showing that the siliceous particles had collected about a fossil nucleus. Between these belts, or rows, is usually a chalky substance easily cut with the knife or even by the finger nail. The so-called "bear-wallows" are where the flint is most abundant and of the best quality, as near the Pillared Palace.

Beside each depression is a pile of ashes with bits of hickory bark. Digging into the wallow, quantities of flint chips were brought to light. Piles of flint blocks abound in which were hundreds of them, each piece having parallel faces, and averaging four inches in length, one or two inches in width and one-half inch in thickness. It was evident to me that they were split by the Indians from the oval nodules as materials for arrow tips or spear heads. We found quartz pounders with which the splitting may have been done; but no manufactured articles except a small saucer cut from sandstone which had once held some black substance. The place was plainly a mine and not a factory. Our search at the mouth of the cave was rewarded by the discovery of quantities of flint chips and also a number of finished arrow heads.

Indian foot-prints were visible in all parts of the new cave when first explored: and I saw them in 1854, although now they are obliterated. The cane torches, so abundant at "Chief City" in Mammoth Cave, which were supposed to be filled with bear's fat when ready for use, are rarely found in Wyandot Cave, which seems to have been lighted by bundles of hickory bark ignited by splinters of various kinds of wood.

What is known as the "Old Cave" was worked by saltpeter miners in 1812, and sundry acts of vandalism have been charged on them, which it is more probable were done by the aborigines. The finest stalacto-stalagmitic column probably in the world is the Pillar of the Constitution at the end of the Old Cave, three miles from the mouth. It is 40 feet high, and 25 feet in diameter, and it rests on a base 300 feet in circumference. The weight of this immense mass of alabaster caused the subjacent rocks to settle, and this in turn cracked the base, opening crevices many yards long, and varying in width from two inches to one foot. A large segment has been cut from the base of this column. Starting from the crevices, an excavation was made cutting a mass from the base having an arc of thirty feet, and making a cavity into the pillar itself ten feet wide, seven feet high and five feet deep. This excavation has hitherto been

regarded as a deliberate plan of the miners to fell the column. But we have a different explanation to offer. Tracing the right edge of the cut we find it running underneath a stalagmitic wrapping, eight feet wide and ten inches thick at its thickest part. Inspection shows that drippings like those now healing this wound were at work before it was inflicted, and that the incision was made through a mass similar to that by which it is at present overlapped. Rothrock's experiments, carefully carried on for a long term of years, fix the rate of stalagmitic growth in this portion of the cave at one inch a century.* Hence the excavation, instead of being made in 1812 must have been completed a thousand years ago. Its age may exceed that, and it cannot be much less. Following the talus of pure white stones that have rolled down under the ledges of black limestone, we find them sometimes cemented over a cavity where nature has had time to produce groups of exquisite stalactites since the quarry was worked, confirming the explanation above given. Further search enabled us to discover the tools with which the ancient workmen wrought, whoever they were, namely, numerous round or oblong granite bowlders, extremely hard, and of a size suitable to be grasped by the hand or twisted in a withe and swung as a maul. They could not have been carried to the end of the cave by the action of water, for it is twenty feet higher than the mouth. The region, moreover, is south of the line of Glacial drift. It seems certain, hence, that they were brought from a distance by persons having access to no better tools. Their ends also are battered and whitened by use as pounders. No manufactured articles were found on the spot; and only shapeless disintegrated fragments were upturned at the mouth of the cave. It is our conclusion that from this alabaster mine, blocks of a convenient size were carried away, perhaps by successive generations, as a choice material for ornaments and images. Those who wrought here by torchlight may have been of the same race that dotted the Ohio valley with mounds, and whose era, according to Mr. C. C. Jones (Mon. Remains of Georgia, p. 59) was synchronous with the date of the mine as estimated in this article. Ornaments of alabaster have been repeatedly exhumed among Indian relics in the Southern States; and more careful research may find similar objects amid the tumuli of Indiana, though perhaps not abundantly. For alabaster, though a very durable material, when not exposed to the elements, is fibrous in its nature, and would be liable to decay amid the frosts and sunshine of ten centuries; as we know from the crumbling specimens found outside in the vicinity of the cave.

* Dr. Binkerd's estimate of stalagmitic growth in Mammoth Cave fixed it at one inch in 7,500 years; which makes Rothrock's estimate seem very moderate indeed! (See Binkerd's Mammoth Cave, p. 54.)

ART. LVI.—*The Chinese Official Almanac*; by Professor MARK HARRINGTON.

THIS document, highly important to about one-third of the human race, is issued annually in December and is carefully prepared by the Board of Astronomy, an important body, imperially appointed, presided over by a prince of the royal blood, and equal in dignity to any other government body in the empire. The Almanac is bestowed as a special act of grace by the emperor on the Coreans, Lewchewans, Annamites and other tributary states. As this publication is so highly respected by the Chinese it may fairly be considered as the representative of the highest state of astronomical science reached by them, and it is therefore worth our while to examine it carefully.

On examining one of these books we find it to consist of two distinct parts, the astronomical and the astrological, the latter being much more fully represented than the former. Taking up first the astronomical part, we find that eclipses of the sun and moon are not mentioned. These are not printed in the Almanac, but, as the writer was informed by an employee of the Astronomical Board, are computed and published just before their occurrence. It is well-known to foreigners resident in China that the predictions are never accurate, but are sometimes as much as an hour in error.

The times of sunrise and sunset are given for forty-eight days in the Chinese year. The dates are from three days to fifteen apart, and the intervals are smallest when the sun is changing his declination most rapidly. The times of rising and setting are very symmetrically arranged and the same hours are repeated from year to year. As it is the hour of rising and setting that is repeated, and as the Chinese month is the lunar one, the dates are changed each year. Were it not for typographical errors the arrangement would appear very accurate and neat. By examining the Almanacs for several years we are able to eliminate the blunders in the plates, and we then make out that the figures are the semi-diurnal arcs of a star having a declination equal to that of the sun on the given date. This is easily seen from the accompanying table (A). The third year of Kuang Hsü began with the new moon in February, 1877, and each successive month with the successive new moons. The fourth year of Kuang Hsü began with the new moon of February, 1878, and the twelve months follow as in the preceding year.

It will be observed that in the rising and setting of the sun as given in this table the corrections are altogether absent.

A.—*Times of Sunrise and Sunset at Peking, as given in the Chinese Almanac, with the corresponding semi-diurnal arcs.*

YEARS 3D AND 4TH OF KUANG HSÜ, 1877–79.

Chinese Month and Day.		Chinese Time of		Corresponding Semi-diurnal Arc.
3d Year.	4th Year.	Sunrise.	Sunset.	
V 11 IV 24	V 21 V 6	4·35	7·25	7·25
V 27 IV 12	VI 8 IV 23	4·38	7·22	7·21
VI 10 IV 3	VI 21 IV 13	4·46	7·14	7·14
VI 19 III 25	VI 30 IV 7	4·54	7·06	7·07
VI 25 III 19	VII 6 IV 1	5·00	7·00	7·00
VII 2 III 13	VII 13 III 24	5·06	6·54	6·54
VII 9 III 7	VII 19 III 18	5·13	6·47	6·47
VII 15 III 1	VII 25 III 28	5·21	6·39	6·40
VII 21 II 25	VIII 2 III 6	5·28	6·32	6·33
VII 27 II 18	VIII 9 II 30	5·36	6·24	6·25
VIII 5 II 12	VIII 12 II 24	5·44	6·16	6·16
VIII 11 II 6	VIII 21 II 18	5·52	6·08	6 08
VIII 17 I 30	VIII 27 II 12	6·00	6·00	6·00
VIII 23 I 24	IX 4 II 6	6·08	5·52	
VIII 29 I 18	IX 10 I 30	6·16	5·44	
IX 5 I 12	IX 16 I 24	6·24	5·36	
IX 11 I 6	IX 22 I 18	6·32	5·28	
IX 17	IX 28 I 12	6·39	5·21	
IX 23	X 4 I 6	6·47	5·13	
IX 29 XII 30	X 10	6·54	5·06	
X 6 XII 24	X 16	7·00	5·00	
X 12 XII 15	X 22 XII 14	7·06	4·54	
X 21 XII 3	XI 2 XII 14	7·14	4·46	
XI 3	XI 14	7·22	4·38	
XI 18	XI 29	7·25	4·35	

The equation of time is disregarded as is common to most oriental nations. This custom takes its origin in the use of sun-dials and is natural when the use of time-keepers is not common. We are not quite justified therefore in looking on the absence of this correction as a fault in the Chinese Almanac. But the corrections for semi-diameter and for refraction are also absent and for their absence we can find no excuse. These corrections at Peking may amount to more than five minutes. The times given in the Almanac are correct only when the corrections neutralize each other, and as that is only twice each year for sunrise or sunset we find that only about four per cent of these predictions are correct in the Almanac.

B.—*Times of Moon's Quartering at Peking, as given in the Chinese Almanac.*

3D YEAR OF KUANG HSÜ, 1877–78.

Foreign date.	Chinese date.	Foreign time.	Chinese time.	Diff.	Foreign date.	Chinese date.	Foreign time.	Chinese time.	Diff.
	I.					VII.			
Feb. 13	1	4·45 P.M.	4·38 P.M.	− 7	Aug. 9	1	1·03 P.M.	1·09 P.M.	+ 6
21	9	12·01 P.M.	11·51 A.M.	−10	16	8	6·14 P.M.	6·13 A.M.	− 1
28	16	3·00 A.M.	2·56 A.M.	− 4	24	16	6·57 A.M.	6·54 A.M.	− 3
Mar. 7	23	5·47 A.M.	2·58 A.M.	+11	Sept. 1	24	5·01 A.M.	5·09 A.M.	+ 8
	II.					VIII.			
15	1	10·40 A.M.	10·40 A.M.	0	7	1	8·46 P.M.	9·00 P.M.	+14
22	8	8·55 P.M.	9·01 P.M.	+ 6	14	8	6·45 P.M.	7·01 P.M.	+16
29	15	1·35 P.M.	1·39 P.M.	+ 4	22	16	11·21 P.M.	11·29 P.M.	+ 8
April 6	23	12·16 A.M.	12·18 A.M.	+ 2	30	24	2·06 P.M.	2·22 P.M.	+16
	III.					IX.			
14	1	1·36 A.M.	1·47 A.M.	+11	Oct. 7	1	5·44 A.M.	6·07 A.M.	+23
20	8	3·23 A.M.	3·38 A.M.	+15	14	8	11·28 A.M.	11·47 A.M.	+19
28	15	12·22 A.M.	12·31 A.M.	+ 9	22	16	3·17 P.M.	3·34 P.M.	+17
May 5	22	7·05 P.M.	7·13 P.M.	+ 8	29	23	10·07 P.M.	10·31 P.M.	+24
	IV.					X.			
13	1	1·15 P.M.	1·26 P.M.	+11	Nov. 5	1	4·34 P.M.	4·59 P.M.	+25
20	8	8·42 A.M.	8·59 A.M.	+17	13	9	7·30 A.M.	7·51 A.M.	+21
27	15	11·51 A.M.	12·04 P.M.	+13	21	17	6·05 A.M.	6·28 A.M.	+23
June 4	23	12·57 A.M.	1·03 P.M.	+ 6	28	24	5·51 A.M.	6·13 A.M.	+22
	V.					XI.			
11	1	10·18 P.M.	10·29 P.M.	+11	Dec. 5	1	5·50 A.M.	6·06 A.M.	+16
18	8	2·10 P.M.	2·20 P.M.	+10	13	9	5·20 A.M.	5·30 A.M.	+10
26	16	12·39 A.M.	12·41 A.M.	+ 2	20	16	7·37 P.M.	7·50 P.M.	+13
July 4	24	4·48 A.M.	4·51 A.M.	+ 3	27	23	2·06 P.M.	2·18 P.M.	+12
	VI.					XII.			
11	1	5·52 A.M.	5·56 A.M.	+ 4	Jan. 3	1	9·49 P.M.	9·51 P.M.	+ 2
17	7	8·58 P.M.	8·57 P.M.	− 1	12	10	2·33 A.M.	2·30 A.M.	− 3
25	15	3·05 P.M.	3·02 P.M.	− 3	19	17	7·57 A.M.	7·55 A.M.	− 2
Aug. 2	23	6·07 P.M.	6·09 P.M.	+ 2	25	23	11·35 P.M.	11·35 P.M.	0

The times of the moon's quarters and of the twenty-four Chinese seasons are also given, and as they are given to the

minute, it is a fair presumption that they are offered as correct. But an Astronomical Board which can not compute the time of sunrise can hardly be expected to be accurate in its calculations on the moon's motions. Table B shows the amount of the error for the last year. The errors are not eliminated when we use apparent time in the foreign times. By examination of the Chinese predictions for two years we find the range of error is from fifteen minutes fast to twenty-six minutes slow, or a total range of forty-one minutes, while the percentage of correct predictions is only three. The character of the errors involved defies solution.

The Chinese year is divided into twenty-four seasons, about fifteen days apart and depending on the sun's right ascension. The most of these, such as "little cold," "great cold," "rain-water," "excited insects," etc., are not recognized by western science, but four of them, viz., the equinoxes and solstices are common to astronomy universal, and can fairly be criticised by foreigners. According to the Chinese the sun is at the vernal equinox at 7 h. 43 m. P. M. According to foreign calculation the Peking time for the same phenomenon is 7 h. 26 m. P. M.,—making the Chinese 17 m. slow. Their summer solstice is 29 m. slow; autumn equinox 49 m. slow; winter solstice 35 m. slow.

The preceding quotations are for Peking; the accompanying foreign times are computed from the British Nautical Almanac and reduced to Peking local time. The position taken for Peking was, longitude 116° 26′ east, latitude 39° 55′ north. The Imperial Almanac also gives predictions for several other points scattered over the empire, but the predictions are more complete and probably quite as accurate for Peking as for the other points.

We come now to the part of the Almanac which the Chinese consult much oftener and consider much more important, viz. the astrological portion. Much of this is made intentionally obscure; for the full comprehension of it a prolonged study of Chinese philosophy and astrology would be necessary,—and a more barren field for scientific research could hardly be conceived. The remainder which makes up the body of the Almanac is intended to be a practical guide in the common affairs of life. The following is a translation of this part for the first few days of the current Chinese year.

The first day is favorable for sacrifice and for entering school; at noon it is allowable to bathe. It is unfavorable for starting on a journey or changing residence.

The second day is favorable for sacrifice and bathing. It is unfavorable for starting on a journey, removing or practising acupuncture.

The third day; there are no indications.

The fourth day; may receive or make visits and cut out clothes; at 7 A. M. may draw up contracts, barter and make presents. May not go on a journey nor break ground.

The fifth day; may visit, bathe, shave and clean up. May not plant and sow.

The sixth day is favorable for sacrifice, conjugal union, visiting, taking on a new servant, starting on a journey, removing, marrying, repairing, building, breaking ground; at 3 A. M. may draw up contracts, open shop, barter, send presents, seal, test the soil and bury.

The seventh day; may level roads but must not start on a journey.

The eighth; may sacrifice, memorialize, enter office, assume ceremonial clothes; at 5 A. M. may sit toward the southeast; also favorable for conjugal union, visits, weddings, taking on a new servant, starting on a journey, erecting uprights and putting on crossbeams, building, removing soil and burying.

And so it goes on for nearly every day in the year. Enough has been translated to show the excessive childishness and absurdity of this, the principal part of the Imperial Almanac. On the 17th one may be treated for illness and open *caches* of provisions. On the 22d it is allowable to pull down old houses and walls but drains must not be opened or wells dug until the 27th. Arrests should be made on the 25th; this is the only favorable day in the month—a very satisfactory arrangement for criminals. There are four days in 30 on which one may cut out clothes and the same number on which one may sweep and clean up. It is advised to shave on the 5th, 23rd, and 29th, and to bathe 7 times in the month. Unfortunately the intervals between the bath-days are unequal, and the believer in the Almanac must wait from the 5th to the 13th and from the 14th to the 23d. Besides on the 1st bathing is favorable at an inconvenient hour, viz. noon; the hour on the 29th (5 o'clock) is much better.

These indications seem too silly to affect sensible men, yet while the Chinaman is not only sensible but actually shrewd and keen, he guides the most of his more important affairs by the Almanac. The poorer classes watch the Almanac carefully and marry, bury and do other things only when it advises, and it is to be feared that the better educated do not start on a journey nor enter office except on favorable days, though it is to be hoped they bathe, shave and clean oftener.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Determination of Carbonic Acid in Mineral waters.*—Borchers has proposed a new method for determining both the free and the combined carbonic acid of a mineral water. He uses in general the apparatus devised for this purpose by Classen, but modified in its details to suit the new method. It consists of a flask to contain the water to be tested, through the cork of which two tubes pass; one a safety tube, ending near the bottom, through which hydrochloric acid can be poured and air aspirated; the other attached to an upright condenser surrounded by a cooling cylinder. From the top of this condenser passes a rubber tube to a U-tube filled with glass beads moistened with sulphuric acid. To this is joined a Liebig's potash bulb, a soda-lime tube and an aspirating bottle. With this apparatus three preliminary experiments were made. In the first, hydrochloric acid of sp. gr. 1·06, was boiled in the flask for an hour, and then air free from CO_2 aspirated through it; the potash apparatus lost 0·0120 gram and the soda-tube gained 0·0115 gram; thus proving the perfection of the apparatus. In the second, a measured volume of cold water saturated with carbonic acid, was placed in the flask and gradually heated to boiling, air being drawn through afterward. The increase of weight of the potash bulb and soda-lime tube, representing the carbonic acid, agreed well with the amount obtained by Fresenius' method; thus proving that the free carbonic acid of a water is entirely driven out by this method of treatment. In the third experiment, it was proved that by sufficient boiling, the carbonic acid combined as acid carbonate (bicarbonate) could be wholly driven off. The analysis is made as follows: The mineral water, previously well cooled, is introduced into the flask by fitting to the bottle containing it, a cork carrying two tubes like those of the ordinary wash-bottle. The flask preferred is of the form known as Erlenmeyer's, a mark being made upon the side to measure the quantity introduced. After connecting it with the apparatus the liquid is heated gradually to boiling, this boiling being continued till the solution in the potash bulb begins to retreat. A liter of air is then drawn through the water, the boiling and the following aspiration being repeated one or more times according to the amount of bicarbonate present. The increased weight of the potash bulbs and the soda-lime tube is then noted, as the free carbonic acid. By means of the funnel tube, hydrochloric acid is allowed to enter the flask slowly to decompose the carbonates. The liquid is then boiled and aspirated as before. The second increase of weight represents the combined carbonic acid. Treating the Selters water in this way, a liter of water gave free carbonic acid 2·4911 grams, combined 0·5699, total 3·0610 grams, against 3·0934 found by Fresenius. Ems

Krünchen gave free CO_2 1·5277, combined 0·6782, total 2·2059 grams. Carlsbad Schlossbrunnen 1·4122 free CO_2, 0·7966 combined CO_2, total 2·2088 grams. Marienbad Kreuzbrunnen 2·6355, combined 0·9055, total 3·5408 grams.—*J. pr. Ch.*, II, xvii, 353, July, 1878. G. F. B.

2. *On Ultramarines of various metals.*—The production from the blue ultramarine containing sodium, of a yellow ultramarine in which the sodium is replaced by silver, was accomplished some time ago by Heumann by heating the former substance, mixed with a concentrated solution of silver nitrate, to 120° in a sealed tube. The attempt to form other analogous ultramarines in this way was a failure. DeForcrand and Ballin have now succeeded in devising a general method of preparing ultramarines containing different metals, and by which they have already produced potassium, barium, zinc and magnesium ultramarines. The process consists in producing the yellow silver ultramarine by the above method and then in heating an intimate mixture of this with the metallic chloride desired. To produce the silver product, the authors heated, for fifteen hours, ten sealed tubes, each containing five grams of blue ultramarine and ten grams of silver nitrate in concentrated solution. On opening the tubes, seventy-five grams of pure silver ultramarine was obtained containing 46·63 per cent. of silver. Under the microscope it appeared a perfectly homogeneous mass of transparent yellow grains. It contained silicon, aluminum, sulphur, silver and oxygen; is insoluble in water, and undecomposable by strong acids. Heated with an intimate admixture of sodium chloride repeatedly, the sodium replaces again the silver and a blue ultramarine is obtained, of a more beautiful shade, and containing less of violet than the original ultramarine; a difference due to the slight loss of sulphur. If potassium chloride be used, a bluish-green ultramarine is produced. Barium chloride gives a yellowish-brown, zinc chloride a violet, and magnesium chloride a gray compound, having all the properties of ultramarine.—*Bull. Soc. Ch.*, II, xxx, 112, August, 1878. G. F. B.

3. *On Chrome Steel.*—Boussingault has made an investigation into the production, the constitution and the properties of the so-called chrome steel. This steel is prepared by mixing in the crucible the required proportions of any suitable steel and an alloy of iron and chromium called ferro-chromium. This alloy is obtained by the direct reduction of chromic iron, and when made in the crucible may contain sixty to seventy per cent of chromium, but only seven to ten when made in a high furnace. The discovery of this steel, the author attributes to Berthier in 1820, and gives extracts from his memoir describing his experiments. He made two chrome steels, one containing 0·010, the other 0·015 of chromium, which were of excellent quality and were worked into cutlery. Boussingault made two experiments to test the question whether chromium alone could give to iron the property of tempering. One of these steels contained 0 010 of chromium and 0·001

of carbon, the other 0·0124 of chromium and 0·0031 of carbon. The first could not be tempered at all, and the other only to the extent of the carbon in it. Further experiments with iridium and osmium showed that these metals could not give to steel the property of hardening. He points out the fact that in 1867 in Antioquia in Central America, a cast iron was made containing from two to four per cent of chromium, and concludes with a description of the process of making ferro-chromium and chrome steel in the works at Unieux.—*Ann. Chim. Phys.*, V, xv, 91, Sept., 1878.

G. F. B.

4. *On the Etherification of the Primary Alcohols.*—MENSCHUTKIN has studied the influence of the isomerism of the alcohols and acids upon the formation of their compound ethers, and in the present paper gives a table showing the percentage of acetic acid etherified by the different primary alcohols at 154°. As to the velocity of this etherification, the first place is taken by methyl alcohol; then follow the primary saturated and then the primary unsaturated alcohols. The author calls the velocity of the reaction during the first hour, expressed in percentages of the ether formed, the starting-velocity. By absolute velocity he distinguishes the ratio between the quantity of the acid or alcohol etherified and the whole quantity taken; by relative velocity the ratio of the portion etherified during the first hour to the whole quantity finally etherified. The absolute starting-velocity of methyl alcohol is 55·59, the relative 80·8. The saturated normal primary alcohols have the same absolute starting velocities, though after the first hour, alcohols with high molecular weight show greater absolute velocities than those of smaller molecular weight. The relative starting velocity lessens with increasing molecular weight in the case of the normal primary alcohols. The influence of isomerism, though distinct in the case of absolute, is more marked in the case of relative starting velocity. The velocity of etherification is less in the unsaturated primary alcohols. To estimate the limit of the etherification, numbers are taken representing the final percentage etherified, beginning with 120 hours. With the exception of methyl alcohol, the percentage increases with the molecular weight. Isomerism affects the velocity of etherification, not its limit. The unsaturated primary alcohols show lower limits than saturated alcohols having the same number of carbon atoms.—*Ber. Berl. Chem. Ges.*, xi, 1507, Sept., 1878. G. F. B.

5. *On the Preparation of Allyl Bromide.*—The present mode of preparing allyl bromide, by dropping phosphorous bromide on dry allyl alcohol, is tedious and possibly dangerous. GROSHEINTZ has shown that this ether may be readily prepared by distilling a mixture of allyl alcohol, potassium bromide and sulphuric acid. The best way is to add to the potassium bromide the sulphuric acid diluted with its volume of water, and to heat the mixture in a distilling apparatus. When the hydrobromic acid begins to be evolved, the allyl alcohol is allowed to fall drop by drop into the liquid. The allyl bromide, which distils over with the vapor of

water, is washed with water slightly alkaline and dried over calcium chloride.—*Bull. Soc. Ch.*, II, xxx, 98, August, 1878.

G. F. B.

6. *On a New Method of preparing Aldehydines.*—LADENBURG showed some time ago that the orthodiamines could be readily distinguished from the meta and paradiamines by the fact that the former produce with aldehyde permanent bases which he called aldehydines. He has now proposed a new and simple method of preparing these aldehydines, which consists simply in agitating a dilute aqueous solution of the orthodiamine hydrochlorate with aldehyde. A tenacious mass is at first formed, which after a long time on standing, or more quickly on adding alcohol, passes into a colorless crystalline hydrochlorate of the new base. Recrystallization gives it pure. The yield is from fifty to seventy per cent.—*Ber. Berl. Chem. Ges.*, xi, 1648, Sept., 1878.

G. F. B.

7. *On the Constituents of Corallin.*—ZULKOWSKY has reëxamined the substance known as corallin and has succeeded in obtaining from it two homologous bodies corresponding to the two homologous rosanilines discovered by Emil and Otto Fischer, the rosanilines being the triamido and the rosolic acids the trioxy-derivatives of a hydrocarbon constituted like diphenylphenylene-methane. The first of these rosolic acids crystallizes in needle masses, dark rose-red by transmitted light, with a magnificent metallic-green reflection. It has the formula $C_{20}H_{16}O_3$. The second is garnet-red, crystallizes in right rhombic prisms, has a blue metallic reflection and affords on analysis the formula $C_{19}H_{14}O_3$. —*Liebig's Annalen*, cxciv, 109, Sept., 1878.

G. F. B.

8. *On a New Organic Base in the Animal Organism.*—SCHREINER has examined a crystalline substance found under various conditions in the animal organism. It was prepared from the spermatic fluid by boiling with alcohol, filtering, drying the residue at 100°, and extracting with warm water containing a few drops of ammonia. On evaporation monoclinic crystals are obtained, which proved to be the phosphate of a new base, whose hydrochlorate had the formula C_2H_5NHCl.—*Liebig's Annalen*, cxciv, 68, Sept., 1878.

G. F. B.

9. *Persulphuric Oxide* S_2O_7.—Since his earlier paper on the subject, noticed in our March number, BERTHELOT has published the results of a more extended investigation of this new compound. The most interesting points established are those connected with its thermal relations. In the fixation of oxygen gas to form persulphuric oxide, heat is absorbed, and hence in its decomposition heat is evolved, and the loss of energy in the successive stages from ozone to oxygenated water, from oxygenated water to persulphuric oxide, and from persulphuric oxide to ordinary oxygen are beautifully traced, the total change being represented by 14·8 units of heat.

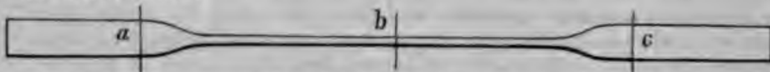
Thus M. Berthelot has furnished us with another illustration of the general principle which his investigations have served so

greatly to illustrate. Persulphuric oxide is an example of a remarkable class of compounds whose formation is attended with the absorption of heat, and whose production can only be determined by the expenditure of some mode of energy. Corresponding to these circumstances of their genesis are the facts that these compounds are very unstable, and that when they decompose into more stable products the heat previously rendered latent becomes free. Now in accordance with the mechanical theory of heat we are forced to the assumption that the expenditure of energy attending the production of such unstable compounds gives to the parts of their molecules a certain energy of position, which energy becomes free when these parts fall back into a more stable equilibrium. But this evidently implies that the molecules have a certain structure, and if so, this structure is a legitimate subject of investigation. We find it therefore difficult to understand why it is that M. Berthelot, while furnishing chemistry with some of the most important facts on which the modern theories of molecular structure are based, should so persistently disparage the results of those who are investigating the same subject from a different point of view, and whose conclusions are, at least, as trustworthy as his own. In the present series of papers, Ann. de Chem. et Phys., July, 1878, Dumas' theory of types is revived and advocated as more philosophical than the generally received doctrine of atomicities, on the ground that it is not so much the nature of the radicals as the so-called *type of combination* which determines the qualities and chemical relations of the resulting products. But in the present state of science what conception can we form of a *type of combination* except as a mode of atomic grouping? and what is the doctrine of atomicities except an attempt at a representation of the habitual mode of grouping of the various atoms, and assuredly the great class of chemical students whose doctrines Berthelot condemns, are all engaged on the one problem of tracing the physical as well as the chemical relations of substances to what they call molecular structure? Lastly, we fail to see what advantage the phrase "type of combination" has over the term "molecular structure." The two expressions suggest the same general thought; but the idea of molecular structure developed as it has been by the investigations of the last ten years, is a more definite conception and one which correlates a vastly larger number of facts than the earlier conception of chemical types, and it must be admitted that the value of a working theory depends solely on its power of correlating facts.

J. P. C., JR.

10. *Acoustic Repulsion.*—In a recent number of the Philosophical Magazine (October, 1878) Lord Rayleigh has given a mathematical explanation of the curious phenomenon of the repulsion of resonators observed by Dvorák and Mayer (Phil. Mag., September, 1878, p. 225.) The conclusion is reached that the resonator tends to move as if impelled by a force acting normally over the area of its aperture and directed *inward.*

11. *Note by* W. Goold Levison, *on the Sand Filter described in American Journal of Science, September,* 1870, *page* 241.* (Communicated.)—A glass rod of a little larger diameter than the aperture in the neck of the funnel is drawn out to a slender thread as shown below.



This is then cut off by the file at the points *a*, *b* and *c*, forming two pieces. The large end of such a piece being held in the flame soon assumes a globular shape, forming a pear of glass. When this is dropped in the funnel the long stem rests against its side. If the funnel be of very thin glass, so as to weigh but little, and the end of the stem be fused fast to its rim, no jar will loosen the sand or precipitate, and it forms, probably, the most convenient filter for drying precipitates at a temperature that would char paper.

II. Geology and Mineralogy.

1. *Note upon the history and value of the term "Hudson River Group," in American Geological Nomenclature;* by James Hall. (Proc. Amer. Assoc., Nashville meeting, August, 1877.)—The term Hudson River Group was employed in the Reports of the New York Geological Survey for the shales and slates overlying the Trenton limestone. Later it was urged by Sir William Logan, and partially admitted by Mr. Hall, that the slates of the Hudson River region were not of the group, but of the Quebec group, and the name Cincinnati group was suggested by Meek and some other geologists as a substitute. Professor Hall here reviews the facts, and states that subsequently he, with Sir William Logan, after an examination of the region, found that the first conclusion was essentially right; that the "Hudson River group continues uninterruptedly from Saratoga County to Kingston in Ulster County, and, on the east side of the river, is clearly defined along the valley, with a width of one to several miles, through the counties of Washington, Rensselaer, and Columbia, its eastern limit approaching the river near Rhinebeck; and he rightly says, that there is no good reason for abandoning the old name "Hudson River Group."

2. *Paleontological Report of the Princeton Scientific Expedition of* 1877; by Henry F. Osborn, Wm. B. Scott and Francis Speir, Jr. 146 pp. 8vo, with 10 plates, 1878.—The expedition from Princeton College last summer to Colorado and Wyoming returned with large and valuable collections of fossils as this Report abundantly shows. The Colorado collections were made in the beds near Florissant, supposed to be Miocene, and in those near the Garden of the Gods "referred to the Dakota and

* In the title of the article, here referred to, Mr. Goold Levison's name is wrongly spelt in two of its letters.

Wealden groups," and those of Wyoming, in the vicinity of Fort Bridger, near Smith's Fork, Henry's Fork and Dry Creek. The species embrace Mammals, Reptiles and Fishes. One of the plates represents a magnificent specimen of the skull of a new species of *Uintatherium*, named *U. Leidianum;* and a second species of the genus is named *U. princeps.* A paper on the geological work of the expedition will appear in another number of this Journal.

3. *The Ancient Life-History of the Earth; a comprehensive outline of the principles and leading facts of Paleontological Science;* by Professor H. ALLEYNE NICHOLSON, M.D., etc. 407 pp. 8vo. New York, 1878. (D. Appleton & Co.)—A very convenient text-book for the geological student.

4. *Manual of Mineralogy and Lithology;* containing the elements of the science of minerals and rocks, for the use of the practical mineralogist and geologist, and for instruction in schools and colleges; by JAMES D. DANA. Third edition rearranged and rewritten. 474 pp. 12mo, with many wood cuts. New York. 1878. (John Wiley & Sons.)—The second edition of this manual appeared more than twenty years since. The new edition now published is a new work in nearly all respects, and yet retains the popular feature of the former in its elementary character, and its arrangement of the ores under the head of the prominent metal they contain. In addition, the chapter on rocks has been expanded into a general but brief treatise on the subject containing descriptions of the kinds and their prominent varieties.*

III. BOTANY AND ZOOLOGY.

1. *Shortia galacifolia re-discovered.*—A hundred years ago the elder Michaux collected, somewhere in the mountains of North Carolina, a specimen of a Pyrolaceous-looking plant, out of flower, or rather with corolla and stamens fallen, a dehiscent capsule enclosed in a persistent imbricated calyx and surmounted by a persistent style. It was not noticed in the *Flora Boreali-Americana*, which was prepared by L. C. Richard from Michaux's collections. Early in the year 1839, I found and examined this specimen in Michaux's herbarium, and I received from the hand of M. Decaisne a drawing and some fragments of it. In a paper treating of the botany of these mountains, contributed to this Journal in January, 1842, I ventured to found a genus upon this plant, under the above name, trusting that the diligent search prosecuted by myself and by all botanists visiting the region would duly bring it to light. The protracted failure of these endeavors has thrown an air of doubt over the minds of my associates in the search, as to the actual existence of any such plant. In 1868, I had the pleasure of announcing in this Journal (Ser. II, xi, 402) the discovery of this genus, not indeed where we were

* That students may not be led astray, it is proper here to say that copies of the old edition have been printed by the former publisher of the work, Mr. H. H. Peck, bearing a recent date on the title page, although unrevised since 1857.

looking for it, but where experience had led me to expect that any or every peculiar Atlantic States type might recur, namely in Japan. That is, I identified the genus with the *Schizocodon uniflorus* of Maximowicz, which, singularly enough, was known only by specimens in the same condition, i. e. with calyx and gynœcium, but neither corolla nor stamens. The patent relationship of these specimens to *Schizocodon soldanelloides* of Zuccarini gave ground for a conjectural restoration of the missing organs; and I ventured the opinion that *Shortia* (of 1842) and *Schizocodon* (1843), whether of one genus or two, were most related to *Diapensia*. In the year 1870 (in Proc. Am. Acad., viii, 243) I reconstructed the order *Diapensiaceæ*, referred to a separate tribe, *Galacineæ*, the genera *Galax* and *Shortia*, and adopted the idea of a probable identity of *Schizocodon* with the latter. The next year Maximowicz decided that the two genera should be distinct, founding this conclusion upon the close seed-coat (confirmed in the Japanese *Shortia uniflora*) and the campanulate corolla, with lobes undulate-crenate instead of fimbriate, and upon some characters in the stamens, all these taken from a rude figure in the Japanese *Soo Bokf.*, iv, fol. 8, which is supposed to represent *S. uniflora*, although the leaves would (as Maximowicz rightly observes) refer it rather to *S. galicifolia*, these being all represented as acute or in one dubious case subcordate at base, instead of reniform-cordate. The identification as to genus is doubtless correct; but the analysis of the flower is too rude for reliance as to all relating to the stamens and the squamulæ. Happily I can now give the characters from an actual blossom.

For I have now received, at first indirectly from Mr. J. W. Congdon, and at length directly from Mr. M. E. Hyams, of Statesville, North Carolina, a flowering specimen of the long-sought *Shortia galacifolia*. Mr. Hyams, or more strictly his son, George McQueen Hyams, collected it on a hill-side in McDowell County, North Carolina, in the district I had indicated as the most probable locality, viz: east of the Black Mountain. It was collected in May, 1877, but, as its remarkable interest was unknown, it has only now been communicated to me. I will only state here, that the distinction between the two genera is probably definite, that our plant is perhaps identical in species with the one figured in the Japanese books (rather than with *S. uniflora*), although the corolla in ours is seemingly white, and the crenulation of the border of the lobes is stronger than in the description and often double; that the anther, though not agreeing with Maximowicz's character, probably may agree with this Japanese representative, and may be generically distinguished from that of *Schizocodon*, unless other species afford transitions; and that the squamulæ are like those of *Schizocodon* and fully as large, but broader, narrowed or almost unguiculate at base, and attached to the very base of the corolla, while the filaments (said by Maximowicz to be "libera," probably in the sense of free from the corolla, as they are represented in the Japanese figure) are adnate to the corolla for most of their length. That is, the phrase "filamentis

tubo corollæ adnatis," in Benth. and Hook. Gen. Pl. is correct, but I know no then extant authority for it, except the analogy with its relatives. Less fortunate are the characters: "Antheræ erectæ, didymæ . . . loculis oblique dehiscentibus," derived by Maximowicz from the Japanese figures, and the "antheræ breves . . . loculis divergentibus" of the Genera Plantarum; the anthers being longer than in any other genus of the order, and the cells in a just sense longitudinally dehiscent. But the anther is,—as in all its relatives except the anomalous Galax,—inflexed or incumbent on the apex of the filament, in this genus about horizontal, as are consequently the marginal sutures which run the whole length of the elongated-oblong cells. The pollen is simple and obscurely trigonous as seen on the field of the microscope. The style and stigma are as in *Schizocodon*, but the latter more capitate. A. G.

2. *On the Amount of Sugar contained in the Nectar of various Flowers;* by A. S. Wilson. A paper read before the Dublin meeting of the British Association, August, 1878.—The interest of this paper lies in the determination of the very small amount of saccharine matter secreted by the nectaries of certain flowers commonly visited by honey bees, and therefore the extraordinary industry of insects in their work of collection; or in other words the vast number of blossoms they must visit (and aid to fertilize) in order to lay up the quantity of honey they do. Mr. Wilson estimates from his data that, to obtain one kilo of sugar from red clover, 7,500,000 flowers must be sucked. There are about sixty flowers in a head; and 2,500,000 visits must be made to collect a pound of honey. (Abstr. from Jour. Botany, London, Oct., 1878.) A. G.

3. *Absorption compared with transpiration.*—In closing a recent article in Ann. d. Sci. Nat., ser. 6, vi, Vesque presents the following abstract of his views.

(1.) Of all the theories advanced to explain the movement of water in plants, that of Boehm is most nearly in harmony with observed facts. [According to Boehm, "the water-movement caused by transpiration is a function of the elasticity of cell-walls, and of atmospheric pressure.]

(2.) Although transpiration is the most potent cause of absorption, these two functions are not necessarily proportional.

(3.) Absorption is equal to transpiration when the plant grows under nearly constant and mean conditions, for instance in diffused light, and in air moderately moist.

(4.) When a plant taken from mean conditions is exposed to dry air, transpiration is more rapid than absorption. It can reach a point at which the plant becomes irreparably injured.

(5.) When a plant taken from mean conditions is exposed to a saturated atmosphere, absorption is more rapid than transpiration, but in proportion as the want of water in the plant is supplied, the transpiration diminishes, and at last the plant is filled to repletion.

(6.) When a plant lacks water, the suction caused by transpira-

tion is not lost; it accumulates to act at once on the roots when water can be had. Then there is observed an absorption more energetic than the transpiration; the absorption diminishes as the want of water is supplied, and finally is governed wholly by the transpiration. G. L. G.

4. *On the causes of the abnormal shapes of plants grown in the dark.*—When deprived of light for a few days, growing plants which contain chlorophyll become etiolated, and undergo changes in form which are often very noticeable. The internodes extend to a greater length than when they grow in light, while the leaves develop only slightly and are often mis-shapen. From the fact that many plants provided beforehand with a store of nourishment, as in the case of corms and bulbs, produce in darkness, flowers of normal color and shape, but at the same time distorted and blanched leaves, the cause of the abnormal growth has been attributed by some to the disturbance in assimilation. Kraus has attributed the abnormal extension of internodes grown in the dark, to an excessive development of the pith and an imperfect development of fibrovascular tissue. He has also observed that the epidermal cells under such conditions have thinner walls than usual. Rauwenhoff, in Ann. Sci. Nat., ser. 6, 5, v. and vi. has reviewed the studies of Kraus and others, and comes to the following conclusions: The longer internodes have, in most instances a longer pith than the others, but that the growth of this cannot be the sole cause of the abnormal extension appears from the case of *Impatiens*, etc., where the pith is wanting. In darkness, the plants experimented upon developed in all parts an unusual amount of fundamental tissue, the tissue to which pith belongs. This abnormal development is attributed to the absence of the retarding influence of light, and to the action of negative geotropism. G. L. G.

5. *Cryptogamic Flora of Silesia: Algæ*, by Dr. OSCAR KIRCHNER, Breslau, 1878.—This forms the first portion of the second volume of the Cryptogamic Flora of Silesia, published under the direction of Professor Ferdinand Cohn, of which the first volume has already been noticed in this Journal. The description of species is preceded by an account of the different works on the algæ of Silesia, and by an article on the general structure of algæ, especially of those growing in fresh water. The first notice of algæ in Silesia appears to be the description by Kundmann in 1736, of an "Oderhaut" or leathery mass growing on the Oder which was found by Gœppert, who examined Kundmann's specimens in 1840, to be formed of *Cladophora fracta*. Flotow, Gœppert, Ehrenberg, Cohn and Hilse have successively contributed to a knowledge of the flora and many of the original species were distributed in Rabenhorst's Algen Europas. On the whole, Dr. Kirchner thinks that less is known about the algæ than about the other cryptogamic groups of Silesia. The descriptive part of the work, embracing more than 250 pages, is well done, the author having been assisted by the notes of his instructor Professor Cohn. The *Florideæ* are treated first, and finally the

Schizosporeæ, the *Diatomes* preceding the latter order, contrary to the usual mode of arrangement. In classifying the *Diatomes* the author has followed Grunow and in the *Nostocs* he has adopted Thuret's classification. It is refreshing to see how the species of Kuetzing and others are united into more rational and comprehensible species. The second part of vol. ii, including the *Lichens* by Stein and the third volume including the *Fungi* by Dr. Schrœter, are announced for 1879. W. G. F.

6. *New York State Museum of Natural History, for the year* 1876: *Report of the Botanist*, CHARLES H. PECK; made to the Regents of the University, Jan., 1877. Published in Sept., 1878, in advance of the Report, pp. 78, and two plates of new *Fungi*.— This 30th annual report follows the 28th, the 29th being still in abeyance on account of some delay in the preparation of the plates. It appears that 168 species have during the year been added to the State Herbarium, of which 129 are Fungi, and 69 of these either new or previously undescribed. At the close of the report Mr. Peck adduces reasons for the opinion that *Lenzites Cookei* Berkl., *L. Cratægi*, *L. proxima*, possibly *L. Klotzschii*, *Dædalea confragosa*, and *Trametes rubescens*, are all forms of one species. A sad account is given of the ravages of a beetle, *Hylurgus rufipennis*, among the Spruces in the Adirondack region. W. G. F.

7. *Professor Eaton's Ferns of North America*, parts 8 and 9.— *Aspidium Lonchitis* and *Woodwardia angustifolia* make up an effective plate. Equally handsome and well executed is the next plate containing *Aspidium fragrans* and *Phegopteris alpestris*. The latter is one of the few subalpine species which are wanting in eastern North America and in the Rocky Mountains, but extend on the western side far down the Sierra Nevada, California. Among others, Sir J. D. Hooker collected it on Mt. Shasta. One would hope that its "fugitive indusium" might be fixed and the plant associated with *Athyrium Filix-fœmina*, which it resembles in habit. The next plate is devoted to delicate or pygmy subjects, *Trichomanes radicans* of Alabama, etc. (said to accord well with the original West Indian species even though the larger Irish *T. speciosum* may be different), and the lilliputian *T. Petersii*. The latter would have made a good show if a fair tuft had been depicted, in addition to the three or four frondlets. *Schizæa pusilla* (misspelled on the plate) is added, in a good figure, with faint and obscure analyses. An entire plate is well given to the Californian *Aspidium munitum*, of which the first figure represents a small form, and the second and third, varieties so peculiar that they would pass for distinct species. Three marked species of *Polypodium* fill the next plate, on which the noble *P. Scouleri* takes by an oversight the name of *P. vulgare*. It must be that the plate-proofs are not revised by the editor before lettering; as he would not let such slips pass. The last plate creditably represents two species of *Pellæa*, *P. andromedæfolia* of the western, and *P. flexuosa* of the southeastern portions of the United States, both extending into South America. A. G.

8. *Sarracenia purpurea*, with five naked rays in place of the umbrella to the style, an interesting monstrosity, was this year detected, near Grantville, Mass., by Mr. Isaac Sprague. The stigmas at the end of the rays are normal; but the branches radiating from the apex of the short style are distinct to the base, the nerve-form axis having merely a very narrow membranous border. A. G.

9. *Professor Alexander Agassiz's Zoological Laboratory at Newport, Rhode Island.*—Professor Agassiz gives the following account of his excellent laboratory in the Annual Report of the Curator of the Museum of Comparative Zoology for 1877–78.—Although summer instruction in Zoology has been abandoned at the museum, I have been able in my new laboratory at Newport to give facilities for work to half a dozen teachers (three ladies and three gentlemen); and it is my intention hereafter to divide the facilities at my command between students of the museum and teachers of our common schools, who must, however, be sufficiently advanced to study for themselves with profit.

The new Laboratory erected by me at Newport is twenty-five feet by forty-five. The six windows for work are on the north side, and extend from the ceiling to within eighteen inches of the floor. In the spaces between the windows and the corners of the building are eight work-tables, three feet by five, covered with white tiles, one foot of the outer edge being covered, however, with black tiles for greater facility in detecting minute animals on a black background. Between the windows, movable brackets with glass shelves are placed; while similar brackets extend across the windows and between the tables, thus providing a shelf at any desired height. The tables for microscope work are three-legged stands of varying height, adapted to the different kinds of microscopes in use. The whole of the northern side of the floor upon which the work-tables and microscope-stands are placed is supported upon brick piers and arches independent of the main brick walls of the building, which form at the same time the basement of the building. The rest of the floor is supported entirely upon the outside walls and upon columns with stretchers extending under the crown of the arches reaching to the northern wall. This gives to the microscopic work the great advantage of complete isolation from all disturbance caused by walking over the floor. This will be duly appreciated by those who have worked in a building with a wooden floor, where every step caused a cessation of work, and was sure to disturb any object just at the most interesting moment. * * * The water is taken some distance from the Laboratory, and drawn up at a horizontal distance of sixty feet from the shore in a depth of some four fathoms, the end of the suction pipe standing up vertically from the ground a height of five feet, and terminating in an elbow to prevent its becoming choked. The water is led through iron pipes coated inside with enamel. From the tank, the salt water is distributed in pipes extending in a double row over the central tables, over the long narrow tables for aquaria, and along the whole length of the glass shelves on the south wall. Large faucets to draw off salt water

e placed at each sink; and by a proper arrangement of valves is possible to lead fresh water to a part of the pipes, in case it needed. The pipes leading over the tables and shelves are ovided with globe valves and nozzles, to which rubber pipe can attached and the water led to a vessel below: there are fifty ch taps, each of which can supply water or air to at least three four jars. The overflow runs into gutters laid alongside the bles, leading into the main drain pipe. To aerate the salt water, ıse an injector invented by Professor Richards of the Institute Technology. This can be used to supply aerated water directly the jar by providing it with a siphon overflow, or the aerated ıter can be collected in a receiver, from which air alone is then l to the jar. This latter course is the only practical one for licate specimens, and for the bulk of the work of raising embryos. ıe east and west sides have large windows and doors provided th blinds; they always remain open, with the blinds closed to ep out sun-light, and serve to ventilate the Laboratory thoroughly. ırge tables for dissection, covered with slate and adjoining a ık provided with fresh and salt water, are placed across the ndows of these sides.

Ever since the closing of the school at Penikese, it has been my pe to replace, at least in a somewhat different direction, the ırk which might have been carried on there. It was impossible · me to establish a school on so large a scale; but I hope, by ring facilities each year to a few advanced students from the ıseum and teachers in our public schools, to prepare, little by tle, a small number of teachers, who will have had opportunities · pursuing their studies hitherto unattainable. The material be obtained at Newport is abundant. The dredging is fair, d not difficult, as the depth in the immediate neighborhood does t exceed twenty to thirty fathoms. The pelagic fauna, however, the most abundant. During the course of each summer, by the e of the dip-net, representatives of all the more interesting marine rms are sure to be found. With my small steam launch, a large ace can always be traversed any evening, and advantage taken the condition of the wind and tide, the launch being amply ge for easy dredging in the moderate depths of the entrance of ırraganset Bay. The Laboratory is placed on a point at the trance of Newport Harbor, past which sweeps the body of water ought by each tide into Narragansett Bay, and carrying with it ery thing which the prevailing southwesterly winds drive before Newport Island and the neighboring shores form the only cky district in the long stretch of sandy beaches extending ıthward from Cape Cod,—an oasis, as it were, for the abundant velopment of marine life along its shores.

V. Miscellaneous Scientific Intelligence.

1. *Report on the Arid Region of the United States; with a ›re detailed account of the lands of Utah;* by J. W. Powell.

196 pp. 4to. With Maps. Ex. Doc., No. 73. Made under the direction of the Interior Department. Washington, 1878.—Prof. Powell here gives an excellent general account of the features, climate and drainage of the great region, describes its agricultural, pasturage and timber lands, and discusses its methods of water supply, and important subjects connected with irrigation. The report also presents a detailed description of the irrigable lands of the various basins, and their present condition, and treats of the government land system needed for the arid region. Mr. Powell's many expeditions over the Rocky Mountain region, under Government auspices, have made him familiar with the country described, and have well fitted him for the preparation of such a work.

2. *United States Geological Exploration of the Fortieth Parallel*, Clarence King, geologist in charge. Systematic geology, by Clarence King. 804 pp. 4to, with 28 plates and 12 analytical geological maps, and accompanied by a geological map and topographical atlas. Submitted to the Chief of Engineers, and published by order of the Secretary of War, under authority of Congress.—We have barely space at this time to announce the publication of this large and very valuable volume on the geology of Western America, by Mr. Clarence King, which closes the author's Rocky Mountain exploration of the Fortieth Parallel.

3. *Annual Report of the Board of Regents of the Smithsonian Institution for the year* 1877. 500 pp. 8vo. Washington, 1878.

4. *The late Professor Henry.*—The family of the late Professor Henry ask to be entrusted with such letters of his, or other MSS. papers, now in the possession of any of his correspondents, as may be of use or interest in the preparation of a memoir of his life. Such letters may be sent to *Mrs. Henry*, care of the Secretary of the Smithsonian Institution, Washington. They will be gratefully received, carefully preserved, and, when desired, duly returned to the owner.

Anales de la Sociedad Cientifica Argentina, entrega ii. Tomo vi. Agoste de 1878. Buenos Aires, 1878.

Report of the Meteorological Service of the Dominion of Canada for the year ending Dec. 31, 1877; by the Superintendent. Ottawa, 1878.

Monographie der Phaneropteriden, von C. Brunner von Wattenwyl; herausgegeben von der k. k. zoologisch-botanischen Gesellschaft in Wien. 401 pp. 8vo. Vienna, 1878.

Science News. Published fortnightly, by S. E. Cassino, at Salem, Mass. First number appeared in November. $2 a year.

Science Observer, Boston. Vol. II. No. 3, appeared in October.

Anales del Ministerio de Fomento de la República Mexicana. Vol. III. November to December, 1877. This volume is largely occupied with the meteorological bulletin of the Central Observatory of Mexico.

Contributions to Paleontology, No. 2, by S. A. Miller and C. B. Dyer, July 22, 1878. Contains descriptions of several new species from the Cincinnati group.

The Paleontologist, by N. P. James, No. 2. Cincinnati, Sept. 14, 1878. Contains notices of Silurian fossils of Ohio.

OBITUARY.

M. Delafosse, Professor of Mineralogy in the Paris Museum of Natural History and the Faculty of Science, died on the 13th of October last.

INDEX TO VOLUME XVI.*

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

H

I

J

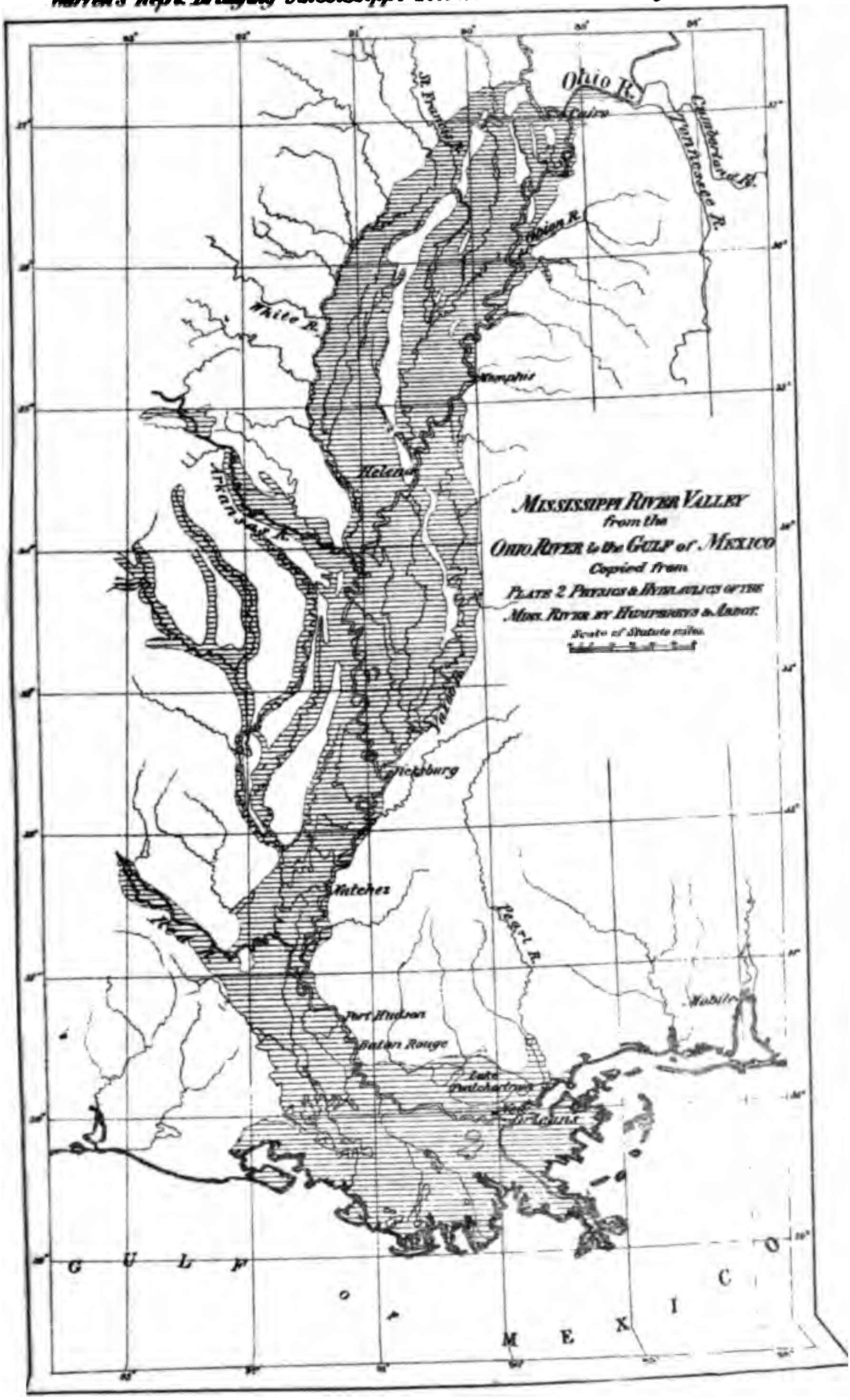
K

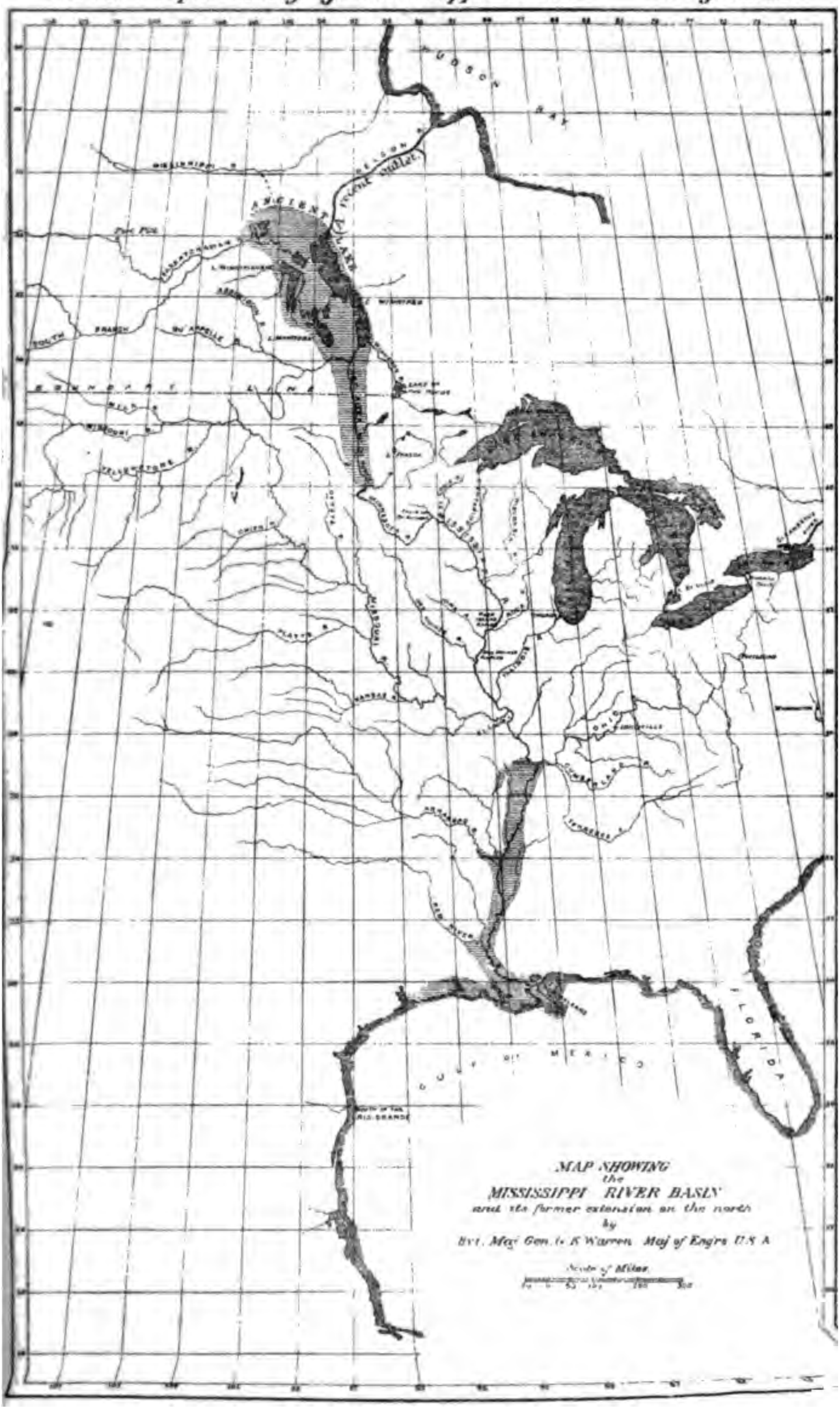
L

M

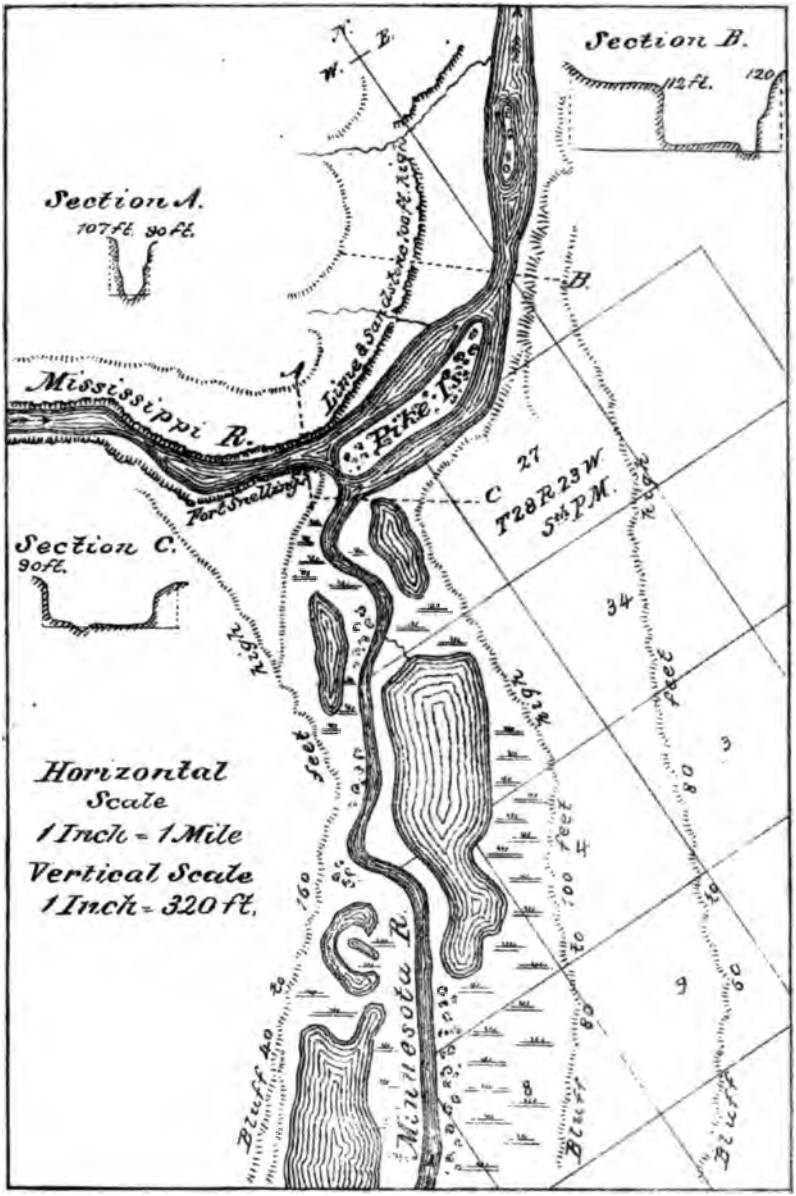
N

Warren's Rep't. Bridging Mississippi River. Diagram A.



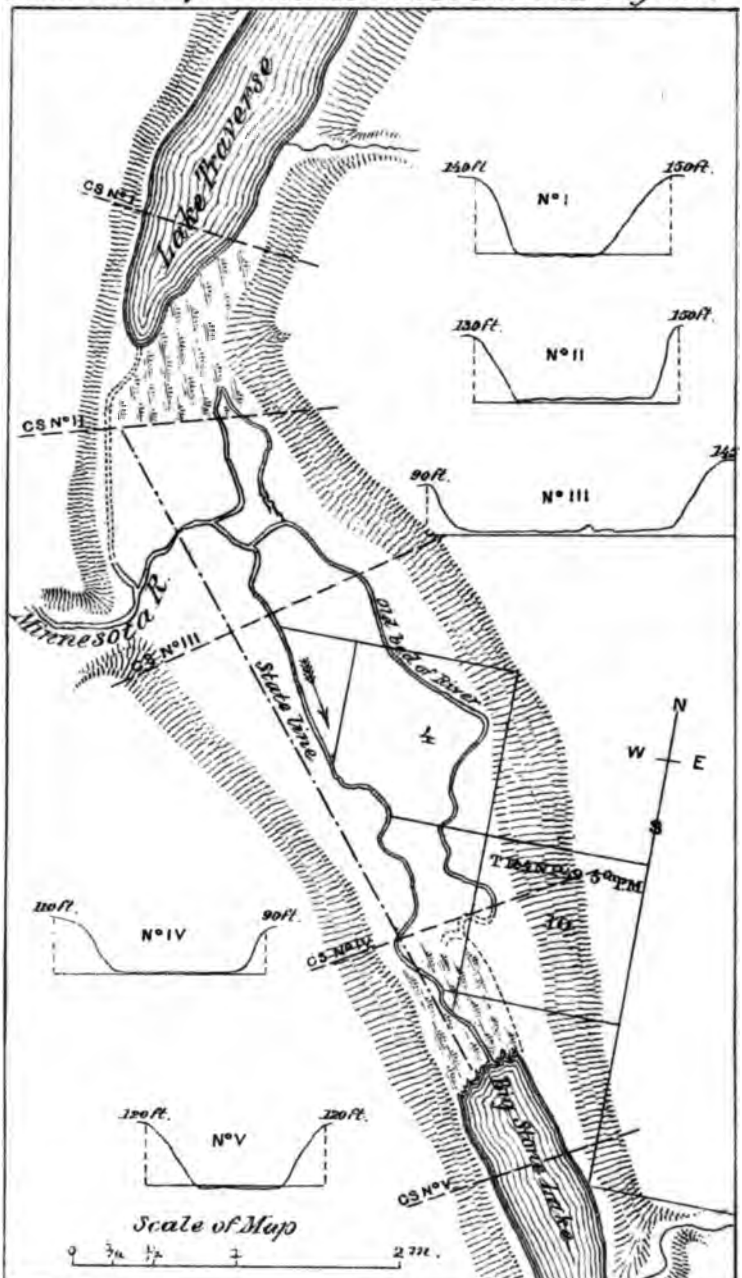

HUDSON BAY
ANCIENT LAKE
Recent outlet
BOUNDARY LINE
GULF OF MEXICO
FLORIDA
MAP SHOWING
the
MISSISSIPPI RIVER BASIN
and its former extension on the north
by
Bvt. Maj. Gen. G. K. Warren Maj. of Engrs U.S.A.
Scale of Miles

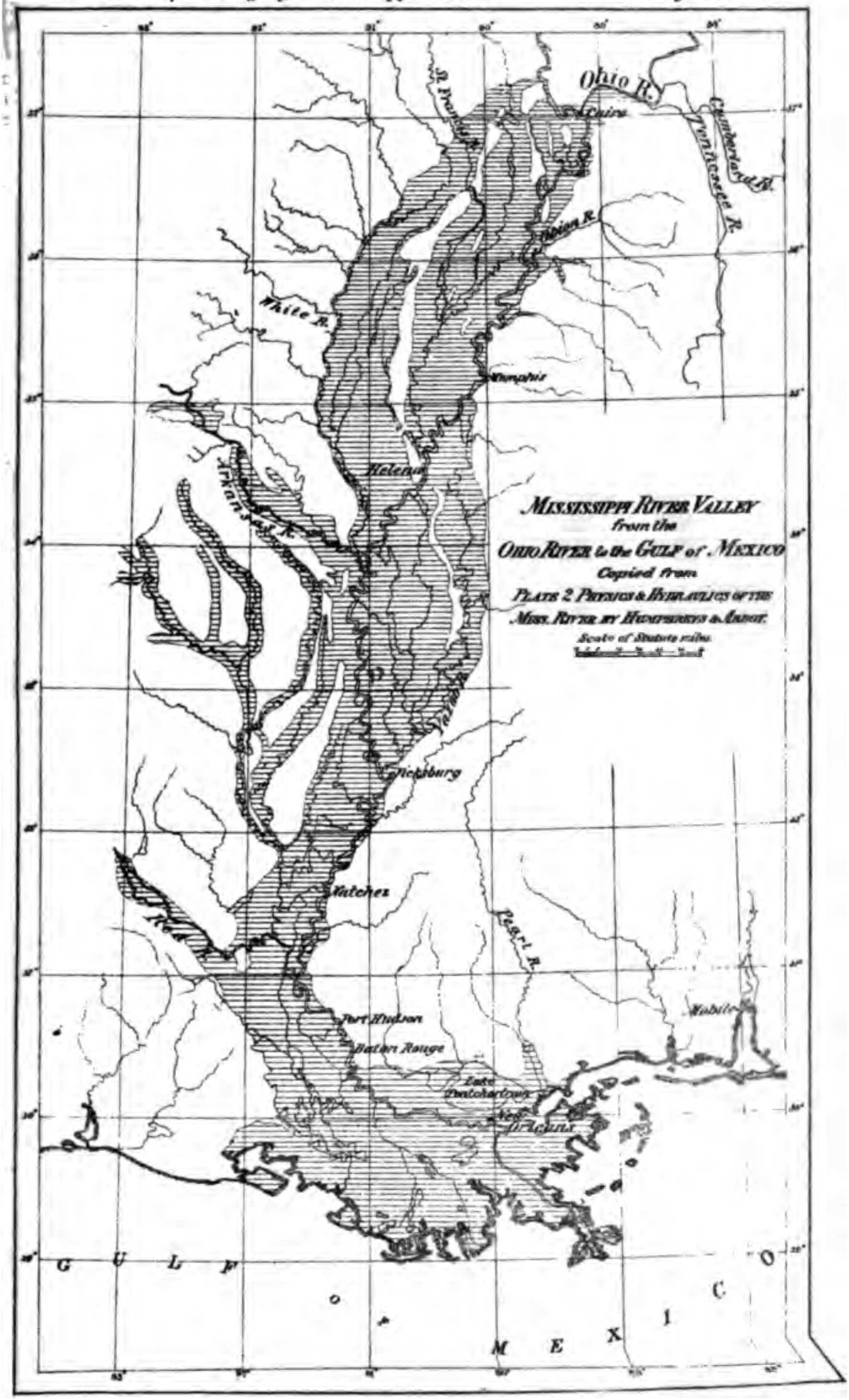
Warren's Rept. Bridging Miss. R. Diagram C.



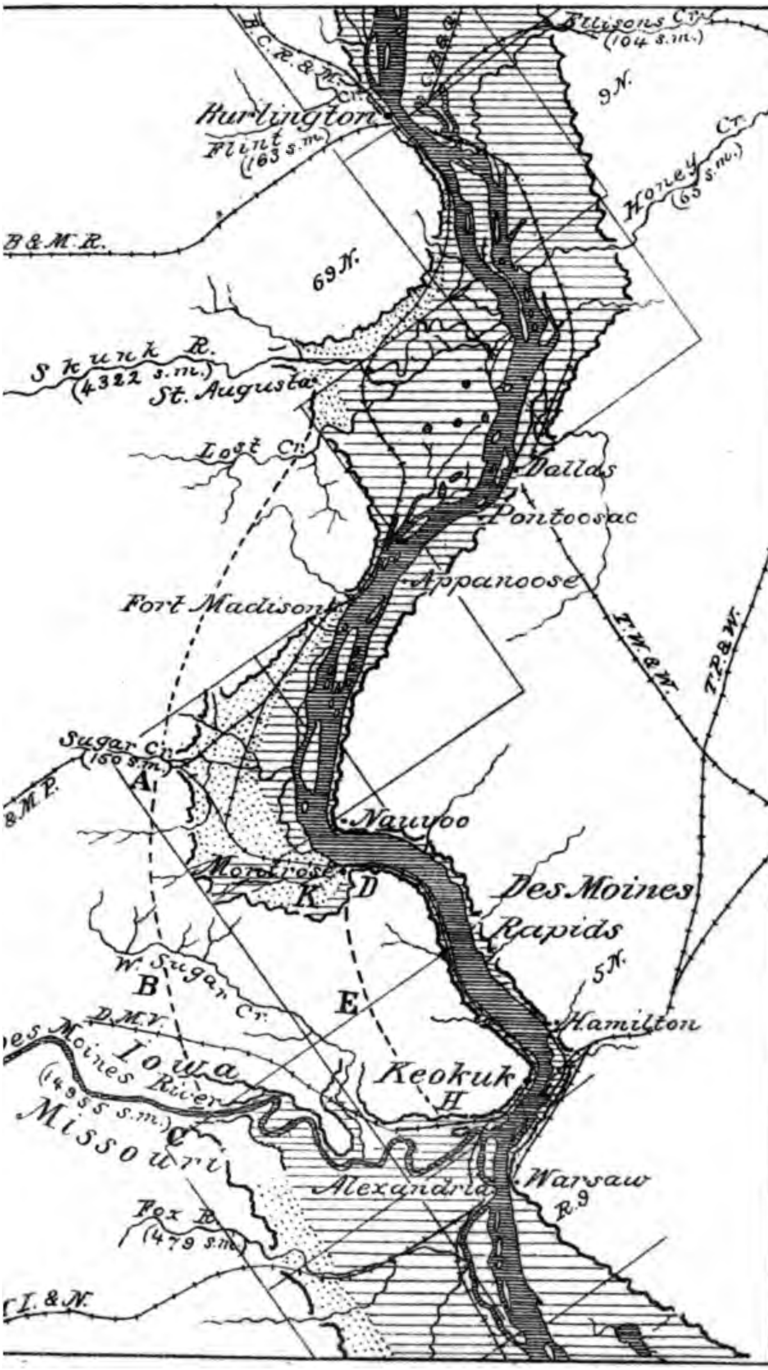
Map showing the river valley where the Minnesota and Mississippi Rivers join, with sections of the valley below the junction, and on each above the junction

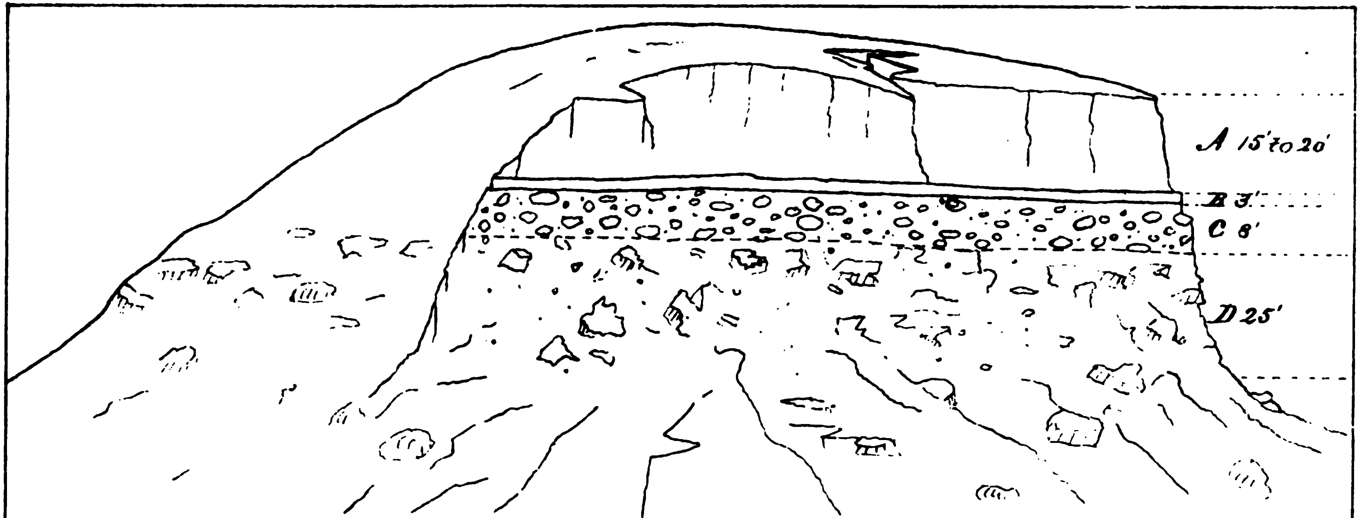
Warren's Report on Minnesota River. Diagram C.




MISSISSIPPI RIVER VALLEY
from the
OHIO RIVER to the GULF of MEXICO
Copied from
PLATE 2 PHYSICS & HYDRAULICS OF THE
MISS. RIVER BY HUMPHREYS & ABBOT.
Scale of Statute miles
Ohio R.
Cairo
Cumberland R.
Tennessee R.
St. Francis R.
Obion R.
White R.
Memphis
Helena
Arkansas R.
Yazoo R.
Vicksburg
Natchez
Red R.
Pearl R.
Port Hudson
Baton Rouge
Lake Pontchartrain
New Orleans
Mobile
G U L F O F M E X I C O

Warren's Rept. Bridging Miss. R. *Diagram E.*

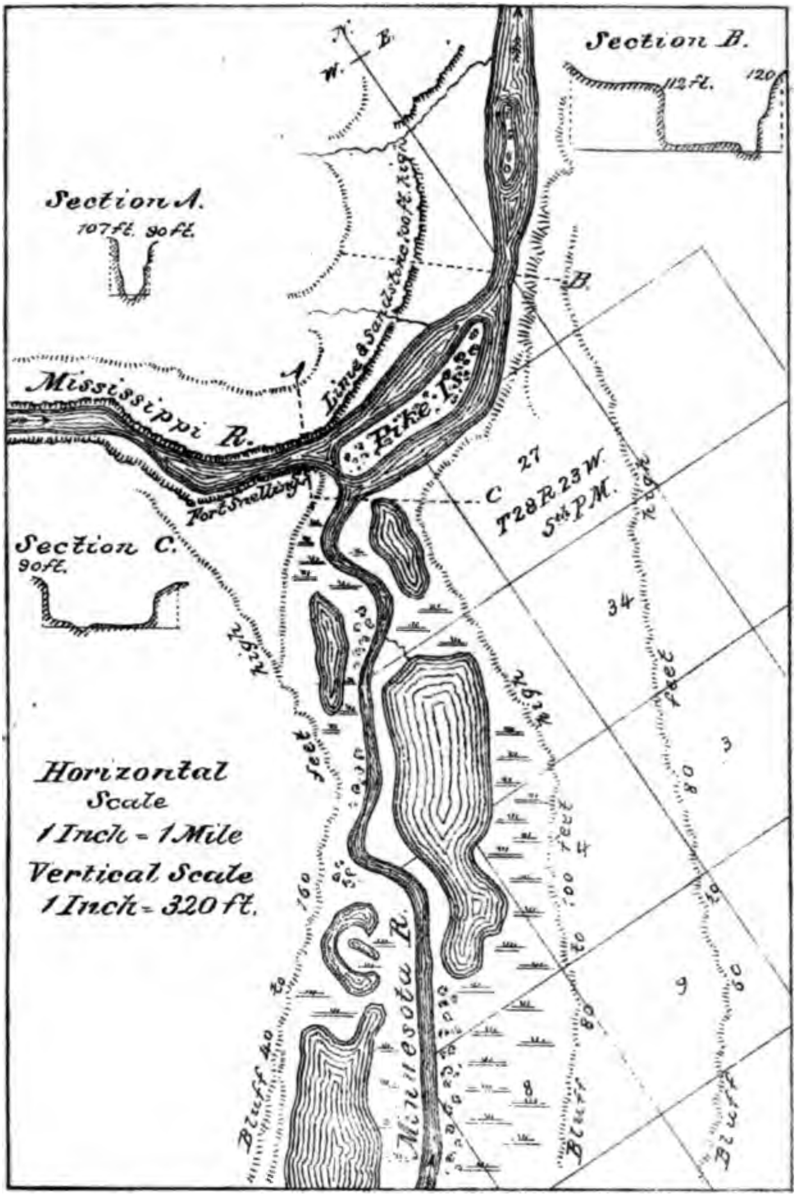




Section of Mississippi River Bluffs at Warsaw Illinois

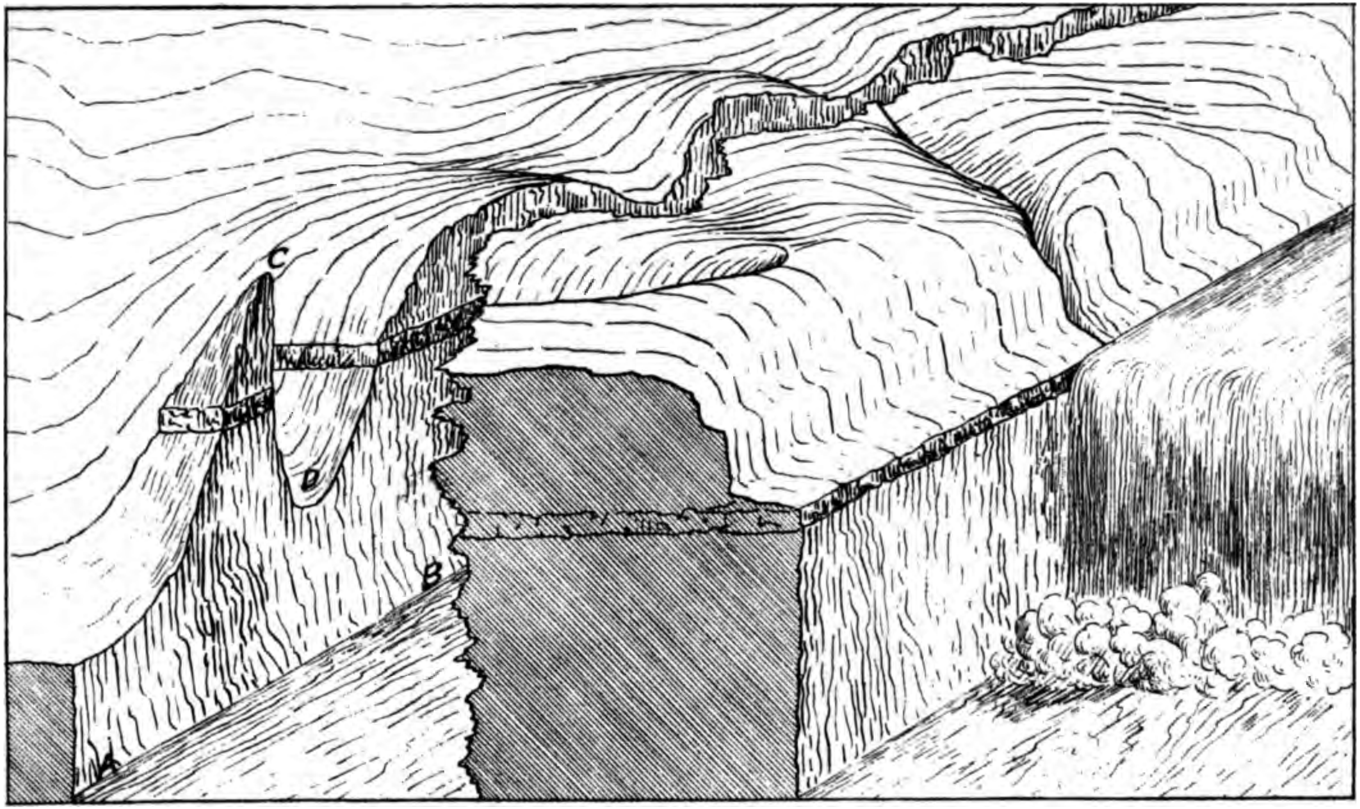
A is a very fine yellow sand and clay widely developed. B is a bluish clay and fine sand C is rounded hard bowlders from small gravel up to 400 lbs., mixed with sand. D is composed of angular blocks from over a ton weight down to small stones, mingled without order; with coarse and fine sand and clay, showing no selection or sorting. The rocks are trap, porphyry, granite gneiss or syenite, hard brecciated limestone &c. The upper carboniferous shales in vicinity exhibit local displacements

Warren's Rep't. Bridging Miss. R. Diagram C.

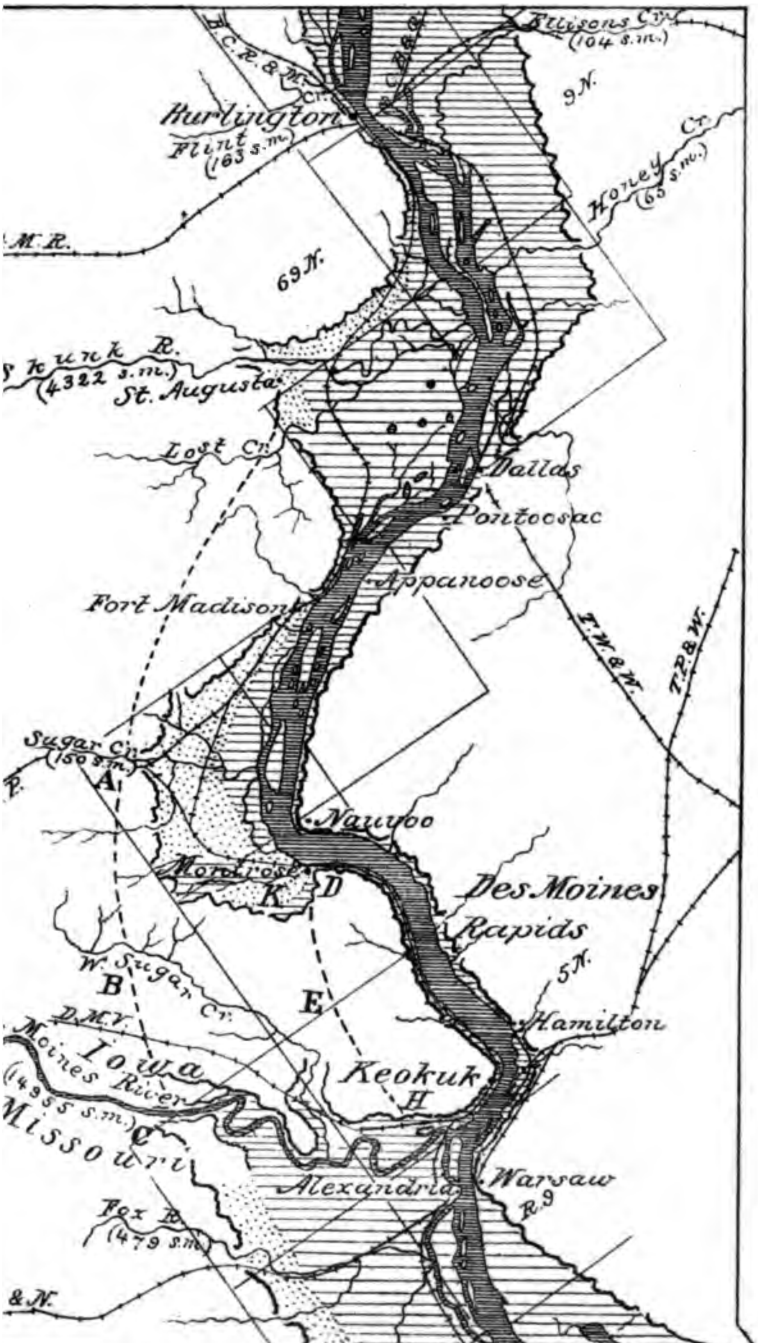


Map showing the river valley where the Minnesota and Mississippi Rivers join, with sections of the valley below the junction, and on each above the junction

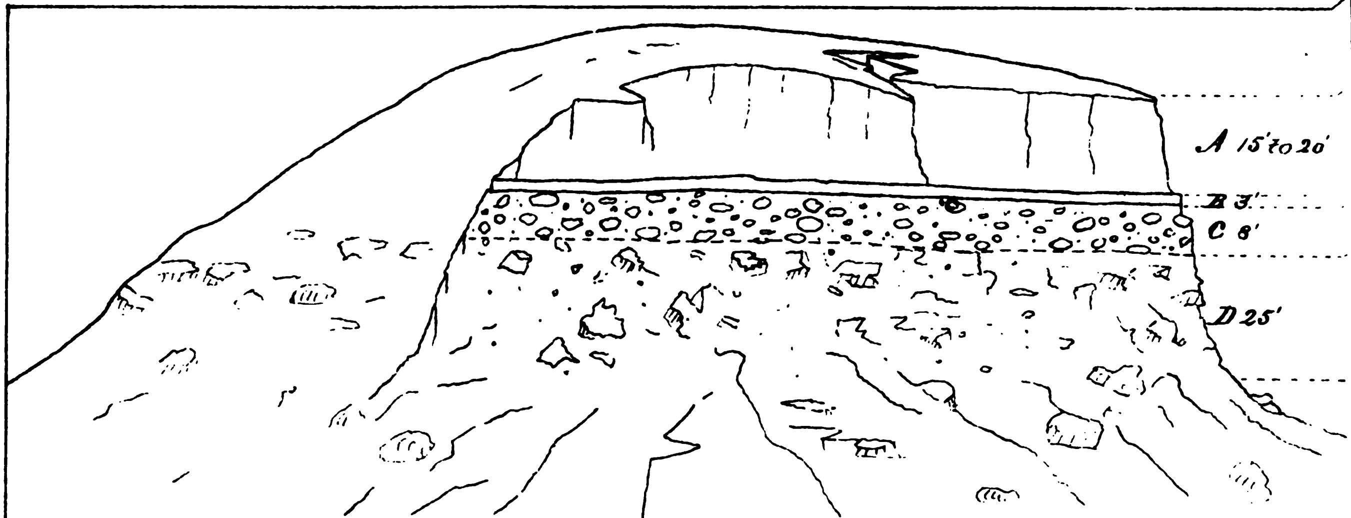
Warren's Rept. Bridging Miss. R. Diagram D.



rren's Rept. Bridging Miss. R. Diagram E.



Warren's Rept. Bridging Miss. R. Diagram F.



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Warren's Rep't Bridging Miss. R. *Diagram G*